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RELATIVISTIC NUCLEAR PHYSICS & QUANTUM CHROMODYNAMICS

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DETERMINATION OF TMD GLUON DENSITY IN A PROTON USING RECENT LHC DATA

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Unintegrated (or transverse momentum dependent, TMD) parton distributions in a proton are important in high energy physics. Using the latest LHC data on the hadron production in pp collisions, we determine the parameters of the initial TMD gluon density, derived in the framework of quark-gluon string model at the low scale $\mu_0 \sim 1 - 2$ GeV and refine its large-x behaviour using data on the $t\bar{t}$ production at $\sqrt{s} = 13$ TeV. Then, by using the Catani-Ciafaloni-Fiorani-Marchesini (CCFM) evolution equation, we extend the obtained TMD gluon density to the whole kinematical region. We apply the proposed TMD gluon density to the inclusive Higgs production in different decay modes, t-channel single top production at the LHC and to the proton structure functions $F_2^c(x, Q^2)$ and $F_2^b(x, Q^2)$ in a wide region of x and Q^2. A good agreement with the latest LHC and HERA data is achieved.

CHECK OF THE STRUCTURE IN PHOTON PAIRS SPECTRA AT AN INVARIANT MASS OF ABOUT 38 MeV/c^2

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Results of an analysis of the effective mass spectra of photon pairs produced in dC, dCu and pC interactions at momenta of 2.75, 3.83 and 5.5 GeV/c per nucleon respectively, are presented. A structure at effective mass of about 38 MeV/c^2 is observed. The results of testing of the observed signal are presented. The test results support the conclusion that the observed signal is the consequence of detection of a particle with a mass of about 38 MeV/c^2 decaying into a pair of photons.

COMPARISON OF THE SPALLATION NEUTRON FIELD ON THE SURFACE OF CARBON AND LEAD TARGETS UNDER THE 660-MEV PROTON IRRADIATION

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Massive carbon and lead spallation targets 19 cm in diameter and 100 cm in length were irradiated with the 660-MeV proton beam from the Phasotron accelerator at the Joint Institute for Nuclear Research (Dubna). A total of 26 depleted uranium and 10 aluminum activation samples were installed on the surface of the targets and they were irradiated with secondary spallation neutrons. Using the methods of gamma-ray spectrometry, we measured the reaction rates of $^{27}Al(n,y_1)$ ^{24}Na, $^{27}Al(n,y_2)$ ^{22}Na, and $^{27}Al(n,y_3)$ ^{7}Be reactions with the effective threshold energies of 5, 27, and 119 MeV. The average neutron fluxes between these energies and the end of neutron spectra were determined. We also measured spatial distribution of the (n, γ), (n,2n), and (n,fission) reaction rates in the depleted uranium samples. These distributions reach a peak at about 10 cm and 345 cm for lead and carbon target, respectively. The ratios of the integral reaction rates of (n,γ), (n,2n), and (n,fission) reactions in uranium samples on carbon and lead targets are 0.24, 2.22 and 1.45. The reaction rates and the neutron fluxes were also calculated with the radiation transport code MCNPX 2.7.0. A relatively good agreement between calculated and experimental data was found.

THE INFLUENCE OF COLLECTIVE EFFECTS ON THE ETA-MESIC NUCLEUS FORMATION

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Joint Institute for Nuclear Research

The formation of the meson nucleus is a secondary effect of the nucleus-nucleus interactions at high energies. The appearance of such a state occurs on the nucleus-residue involved in the primary collision. Multiple studies have shown that the nucleus-residue is in an excited state. In the case of a sufficiently large number of nucleons in the nucleus-residue, this state is the excitation of the collective type, during which large groups of nucleons of the nucleus move correlated. Thus, to describe the process of meson nuclei formation it is necessary to involve adequate collective models. Taking into account the collective effects in the nucleus can significantly affect the reaction.

In this paper we consider the processes associated with the formation of the meson nucleus on the excited nucleus-residue. The resonant character of the formation of such a system is shown. Calculations of the resonance position for a set of nuclei and comparison of the calculated values with experimental data are presented.

CMS: PHYSICS OVERVIEW

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An overview of physics results from the CMS experiment at the LHC is given. The present analysis is based on data obtained for colliding proton beams at the c.m. energies of $\sqrt{s} = 8$ and 13TeV over the period of LHC Run-1 and Run-2.

New unique data on interactions of Standard Model particles at record energies were obtained in the course of the first run of LHC operation. The Higgs boson was discovered, and investigation of its properties was initiated. Long-range correlations were observed in proton-proton and proton-nucleus interactions. Measurements were performed for Standard Model processes, including rare and previously unobserved (associated tW production) ones, and for the decay process $B_s \to \mu^+\mu^-$. This permitted refining some parameters of the Standard Mode and setting limits on the parameters of some theoretical models beyond the Standard Model, for example, on the masses of new particles, on the fundamental energy scales, on the coupling constants, and on the cross sections for the production of new particles.

The results of the CMS experiment that are discussed in the present talk agree with the results of the ATLAS experiment, which is the other multipurpose experiment at the Large Hadron Collider.

RECENT DEVELOPMENTS IN PARTICLE YIELD FLUCTUATION MEASUREMENTS

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In relativistic heavy-ion collisions, properties of the initial state and effects arising during evolution of the medium, such as a transition between the hadronic and partonic phases, should reflect themselves in event-by-event fluctuations of the number of produced particles and correlations between particle pairs. In this talk, recent measurements of several event-by-event observables, performed by the ALICE collaboration in Pb-Pb collisions, namely, dynamical fluctuations of relative particle yields and forward-backward mean transverse momentum correlations, are discussed. Also, a set of new observables for forward-backward correlation studies is proposed. One of these observables measures correlations between ratios of identified particle yields in two separated rapidity intervals, another one is the correlation between the ratio in one interval and average transverse momentum in the other. With such observables it is possible, for instance, to study correlations between strangeness production and the density of the fireball formed in AA collisions. It is shown that these measures possess useful properties from the experimental point of view, such as robustness to volume fluctuations and detector inefficiencies. It is demonstrated how the so-called Identity Method, a novel experimental technique which allows to solve the problem of particle mis-identification, can be utilized for experimental determination of the correlation strengths.

THE SYMMETRY ENERGY IN NEUTRON STARS: CONSTRAINTS FROM GW170817 AND DIRECT URCA COOLING

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In this contribution I will review the state of the art measurements for the symmetry energy from both astrophysical and terrestrial laboratories. In particular the recent detection of gravitational radiation from the GW170817 event shed light on the properties of the neutron star equation of state, thus comprising both the study of the symmetry energy and stellar radius. Furthermore, I shall address the question on the possibility of a universal symmetry energy contribution to the neutron star equation of state under restricted Direct Urca cooling. When these two aspects are combined, powerful predictions for the neutron star equation of state are obtained.

STUDY OF LIGHT NUCLEI FRAGMENTATION IN NUCLEAR TRACK EMULSION AND SIMULATION IN THE BECQUEREL EXPERIMENT

D.A. Artemenkov

Joint Institute for Nuclear Research

The report will give a brief overview of the experimental results of the relativistic fragmentation of ^{7,9}Be, ^{10}B, ^{10,11}C in the Becquerel project in JINR. The questions of simulating nuclear-nuclear interactions in nuclear track emulsions using Geant4 will be considered. The experimental data will be compared with the simulation. Issues of application of Geant4 to planning and preparing experiments using nuclear track emulsions are discussed.

THE IDEAS OF A.M. BALDIN ON OVERCOMING THE REDUCTIONISM PRINCIPLE IN RELATIVISTIC PHYSICS

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The reductionism principle and the role of the Standard Model in the general paradigm of modern physics are discussed. The structure of the laws of nature is considered based on the idea of symmetry (starting with the Curie causality principle to the specific symmetries in relativistic physics).

The criteria of applicability of variables used for description of relativistic nuclear collisions and the ideas of A. M. Baldin on the notion "elementary particle" are discussed. The notions of "locality" of interaction and definition of relativistic collective effects are considered. Particle production is considered using the main parameter of the Lobachevsky geometry, the angle of parallelism.

Some possible physical experiments aimed at detection of new fundamental regularities at the LHEP accelerator complex and the NICA collider are presented.

SELF-SIMILARITY APPROACH FOR PREDICTION AND ANALYSIS OF EXPERIMENTS AT THE ACCELERATOR COMPLEX NICA

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The given functional self-similarity solution quantitatively describes angular, energy and A-dependences of inclusive production cross sections for hadrons in relativistic nuclear collisions. It is applied for quantitative estimation of φ, J/ψ and D meson, as well as light fragment, production in collider experiment at NICA accelerator complex with heavy and light nuclei. The results can be used for optimization of particle registration in experiment.

The extension of the self-similarity description to production of particles with high transverse momentum is discussed.

EVENT RECONSTRUCTION IN THE BM@N EXPERIMENT

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In the report the main accent is put on development of software to be used within the BM@N experiment consisting as a first step towards a fulfil realization of fixed target program at the NICA complex. A brief description of the software used for reconstruction of track / hits parameters in the inner tracker of the experiment is given in the report. Some utmost urgent point like alignment procedure in automatic mode being made with the Millepede package fully integrated in the software is considered. Results illustrating a quality assurance of alignment performed within existing experimental data obtained from carbon / argon experimental runs and recent results (primary and secondary vertex estimation, strange resonance reconstruction ...), including methodological ones, got from a tracking procedure we are using for event reconstruction in the inner tracker are also presented. In addition to all mentioned above, importance of a precise geometry description, a realistic detector response via microsimulations done for the GEM part of the inner tracker in order to be subsequently used when processing experimental data and our recent progress on this activity are discussed within the report.

MONTE CARLO GENERATOR DQGSM

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The Dubna Cascade and Quark-Gluon String Models are modified in the new developed universal Monte-Carlo code, DQGSM, for simulation of hadron-nucleus and nucleus-nucleus reactions at energies from hundred MeV to hundreds GeV per nucleon. It can serve as an effective tool for estimation of physical effects in heavy ion collisions and for planning of detector setup. New physical mechanisms and effects, like hyperfragments production, vorticity and hyperon polarization are implemented into the code. We briefly describe the main ingredients of the model, give essential technical details of the code such as the input parameters, the structure of the input and output files and provides necessary information for a practical use of the code.

TSALLIS STATISTICS AND HEAVY QUARK TRANSPORT IN QUARK GLUON PLASMA

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Power law formulae have routinely been used to describe the transverse momentum spectra of the hadrons at high energies. The Tsallis distribution is one among them which has been very successful in explaining the experimental transverse momentum distribution, longitudinal momentum fraction distribution as well as the rapidity distribution of the hadrons in electron-positron and proton-proton collisions. The Tsallis distribution is a two parameter power-law distribution, described by the Tsallis parameter q (which can be related to the relative variance in temperature) and the Tsallis temperature T, which reduces to the Boltzmann (exponential) distribution when q goes to 1. The Tsallis distribution has been used in many fields of the physical as well as the social sciences (like Statistical Mechanics, Geology, Anatomy, Economics, Finance and many more). In the realm of the physical sciences it arises when there are systems with non-ideal effects like long range correlation, memory effect etc. Quark-Gluon Plasma (QGP), the hot and dense medium created during the high energy collision phenomena, is one such example. This medium has been under intensive study for the past few decades and characterising such a system with the transport properties of the heavy quarks (like charm and bottom) is also a very active field of research. After reviewing some basic aspects of the Tsallis non-extensive statistics, modification of the transport properties of the heavy quarks in Quark Gluon Plasma in presence of the Tsallis statistics will be discussed.

FAST NEUTRON FLUX MEASUREMENT IN THE ENERGIES RANGE FROM 10 TO 100 MEV IN THE QUINTA ASSEMBLY AFTER SHORT PROTON IRRADIATION

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The monitoring of fast neutron fields is going to be more and more important especially with the introduction of advanced nuclear systems such as Generation IV fast reactors, accelerator-driven systems and spallation neutron sources generally. This work was a part of the international project „Energy plus Transmutation of Radioactive Wastes“ (E+T – RAW) for investigations of energy production and transmutation for radioactive waste of atomic energetic. In the 2017 was caried three experiments on Quinta assembly. One of them it was short 20 minutes proton irradiation, specially for search short live isotops. Yttrium 89 samples were located in the QUINTA assembly in order to measurement of average high neutron flux density in five different energy ranges. Our paper have shown the isotops production and average neutron flux density from 10 MeV to 100 MeV inside the experimental assembly. Production of yttrium isotopes decreases in higher energies what meets theoretical expectations concerning cross sections and neutron spectrum.

MEASUREMENTS OF THE INVARIANT CROSS SECTIONS FOR FORWARD PRODUCTION OF THE SECONDARY LIGHT NUCLEI IN CC-COLLISIONS AT BEAM ENERGY 20.5 GeV/n ON THE ACCELERATOR U-70 IHEP

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The mesurements of the invarinat cross sections for forward production of the secondary light nuclei in CC-collisions at beam energy 20.5 GeV/n have been made on the accelerator U-70 (National Research Center Kurchatov Institute - Institute for High Energy Physics, Protvino, Moscow region, Russia) with employing the beamline no. 22 together the detectors of the FODS setup as spectrometer with verying beam line rigidity from 7 to 70 GeV/c. In the experiment observation of secondary light nuclei with momenta above kinematic limit of NN-interactions have been obtained. Recalculations of the observed yelds of particles to the invariant cross section were performed with detaled simulation for propagation of particles and nuclei through the beam line no. 22 and the FODS detectors in the framework of Geant4. This approach allows to estimate both the angular aperture of the experiment and the loss of particles and nuclear fragments due to its decays and interactions in the material of the setup. A wide class of theoretical models introduced in Geant4 (like QGSP-FTFP-BERT-EMV) allows one to compare their predictions related to invariant cross section directly with experimental results and select models that are more appropriate to reality with possibility of refinement and adjustment of the model parameters.

RECENT RESULTS FROM THE BESIII EXPERIMENT

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BESIII is a 4π magnetic spectrometer taking data at the BEPCII electron-positron collider in Beijing, China. The collision energy varies between 2.0 and 4.6 GeV while the peak luminosity reaches 10^{33} cm$^{-2}s^{-1}$. The huge data samples collected by BESIII allow detailed studies in different fields, including charmed mesons and baryons, charmonia states, light meson spectroscopy, tau-leptons, "XYZ" charmonium-like mesons and many others. In this talk I present the recent BESIII results based on the world record high statistics collected in the energy domain of charmonium and open charm.

OBSERVATION OF DECONFINEMENT IN A COLD DENSE QUARK MEDIUM

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We present the recent results on the confinement/deconfinement transition in lattice SU(2) QCD with two flavors of quarks at finite quark density and zero temperature. In the region $\mu_q \sim 1000$ MeV we observe the confinement/deconfinement transition which manifests itself in rising of the Polyakov loop and vanishing of the string tension σ. After the deconfinement is achieved at $\mu_q > 1000$ MeV we observe a monotonous decrease of the spatial string tension s which ends up with s vanishing at $\mu_q > 2000$ MeV. To study the properties of cold dense quark medium we measure the dependence of chiral and diquark condensates, quark density, topological susceptibility and other physical quantities on the chemical potential.

POSSIBLE SIGNALS OF TWO QCD PHASE TRANSITIONS AT NICA-FAIR ENERGIES

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During last few years our group developed the most advanced model of the hadron resonance gas [1] which not only allowed us to achieve the best description of all hadronic multiplicities measured from the lowest AGS to the highest RHIC energies, but also to reveal the remarkable irregularities at chemical freeze-out [2-5]. It is intriguing that in central nuclear collisions we found two sets of similar irregularities. The most prominent of them are the sharp peaks of the trace anomaly and baryonic charge density existing at chemical freeze-out at the center-of-mass energies 4.9 GeV and 9.2 GeV [2, 5]. They are accompanied by two sets of highly correlated quasi-plateaus in the collision energy dependence of the entropy per baryon, total pion number per baryon, and thermal pion number per baryon which are found at the center-of-mass energies 3.8–4.9 GeV and 7.6–9.2 GeV [2-4]. The low-energy set of quasi-plateaus was predicted a long time ago. On the basis of the generalized shock-adiabat model I show that the low-energy correlated quasi-plateaus give evidence for the anomalous thermodynamic properties inside the mixed phase found at the center-of-mass energies 4.3–4.9 GeV. Furthermore, based on the thermostatic properties of the mixed phase of a 1-st order phase transition and the ones of the Hagedorn mass spectrum I will explain, respectively, the reason of observed chemical equilibration of strangeness at the collision energy 4.9 GeV and above 8.7 GeV. Also I will argue that the both sets of irregularities possibly evidence for two phase transitions, namely, the 1-st order transition of chiral symmetry restoration in hadronic phase at low-energy range and the 2-nd order deconfinement transition at the higher one. In combination with a recent analysis of the light nuclei number fluctuations our results indicate that the center-of-mass collision energy range 8.8-9.2 GeV may be in the nearest vicinity of the QCD tricritical endpoint [5]. Also I will discuss the properties of the phase of massless hadrons existing between two phase transitions.

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RECENT PROGRESS IN COMPUTATIONAL STUDIES OF RADIATION-INDUCED DISORDERS IN THE CENTRAL NERVOUS SYSTEM

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Modern accelerators provide extensive capacity for multifaceted radiobiological research concerning fundamental problems of radiation genetics, molecular radiobiology, and radiation physiology, as well as a wide spectrum of practical issues, the most challenging ones being space radiobiology with special reference to manned interplanetary missions and the use of charged particles for the treatment of malignant tumors. Possible acute and delayed risks to the central nervous system (CNS) are accepted now as the most concerning in these fields. The aim of this report is to explain basic approaches for solving the problem of radiation-induced disorders in CNS and estimating expected risks. Special emphasis will be given on current progress in theoretical studies using multi-scale computer modelling techniques, such as Monte-Carlo particle track simulation, biochemical kinetics, molecular dynamics, and simulation of biological neural networks.

PROBING QCD WITH THE ATLAS DETECTOR

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The production of inclusive jets and di-jets at hadron colliders provides a stringent test of perturbative QCD at the highest energies. The process can also be used to probe the gluon density function of the proton. The ATLAS collaboration has measured the inclusive jet production cross section in 20.3 /fb of data collected at a center-of-mass energy of 8TeV and in 3.2 /fb of data collected at a center-of-mass energy of 13TeV. The measurements have been performed differentially in jet rapidity and transverse momentum. The collaboration also presents a measurement of the di-jet cross section at a center-of-mass energy of 13TeV as a function of the di-jet mass and rapidity-difference. The results have been compared with state-of-the-art theory predictions at NLO in pQCD, interfaced with different parton distribution functions. Moreover, we present two measurements of dijet correlations allowing to test the renormalization group equation and extracting the strong coupling constant. The talk concludes with the latest results of jet-substructure studies at 13 TeV, in particular the measurement of the jet soft-drop mass as a first jet-substructure observable which can be predicted with perturbative calculations.

CHARMED BARYON STUDIES VIA LATTICE QCD

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In this talk, I will introduce our group's last five years of effort on studying the charmed baryons. I will go through some selected results on charmed baryon form factors [1, 2, 3] and radiative transition dynamics [4, 5, 6] and discuss our on-going calculations as well as future perspectives.

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SYMMETRY AND KINEMATIC HIERARCHY FOR PARTICLE REACTIONS

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We consider general spin particle formalism based on symmetry properties. In such approach obligatory kinematic factors arise in helicity amplitudes and consequently in expressions of all observable quantities. We get many old end several new results for spin-particle reactions.

We discuss pp elastic scattering at high energies and large fixed angle. This is the region of hard collisions where perturbative QCD must work. PQCD predicts "the helicity conservation" which gives a zero polarization and the value 1/3 for asymmetry parameter which are in contradiction with the experiment. In our approach kinematic factors give small parameters in the considered region. These parameters suppress contributions of definite helicity amplitudes in observables. This "kinematic hierarchy" gives the nonzero polarization and is closer to the experimental value for than QCD.

THERMODYNAMIC LIMIT IN HIGH-MULTIPLICITY $PP, PPB, PBPB$ COLLISIONS

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An analysis is made of the particle composition in the final state of $pp, pPb, PbPb$ collisions as a function of the charged particle multiplicity ($dN_{ch}/d\eta$). The thermal model is used to determine the chemical freeze-out temperature as well as the radius and strangeness suppression factor γ_s. Three different ensembles are used in the analysis. The grand canonical ensemble, the canonical ensemble with exact strangeness conservation and the canonical ensemble with exact baryon number, strangeness and electric charge conservation. It is shown that for the highest multiplicity class the three ensembles lead to the same result. This allows us to conclude that this multiplicity class is close to the thermodynamic limit. It is estimated that the final state in pp collisions could reach the thermodynamic limit when $dN_{ch}/d\eta$ is larger than twenty per unit of rapidity, corresponding to about 300 particles in the final state when integrated over the full rapidity interval

NUCLEON STRUCTURE STUDIES WITH THE PANDA EXPERIMENT AT FAIR

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The PANDA experiment is one of the major projects in preparation at the upcoming FAIR facility in Darmstadt, Germany. A multipurpose high energy physics detector is currently under construction and will be operated at the High Energy Storage Ring of FAIR. High intensity antiproton beams will be available in the momentum range between 1.5 GeV/c and 15 GeV/c and will allow to address a broad physics program including hadron spectroscopy, search for charm and strangeness in nuclei, hypernuclear physics and other QCD topics. In addition, the PANDA experiment will offer unique possibilities to investigate the structure of the proton in a very challenging regime (time-like region) with a large number of electromagnetic processes. In this talk, the PANDA physics program related to the nucleon structure aspects will be discussed. Feasibility studies of proton structure observables at PANDA, such as the proton electromagnetic form factors in the time-like region and the nucleon-to-meson transition distribution amplitudes, will be reported.

INCOMPLETE FRACTAL SHOWERS AND RESTORATION OF DIMENSION

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The $SePaC$ and BC methods are used for fractal analysis of mixed events containing incomplete fractals. Reconstruction of the distribution of events by dimension D_F is studied. The procedures for analyzing incomplete fractals and correcting the determination of D_F of combined fractals by the SePaC method are proposed. We find that the $SePaC$ method fully reconstructs incomplete fractals and suppresses background, separation of incomplete fractals and background by the BC method depends on the basis of the formation of the fractal, and the distribution of events over the value of D_F is more accurately reconstructed by the $SePaC$ method in comparison with the BC method.

ρ MESON GENERALIZED PARTON DISTRIBUTIONS

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The generalized parton distributions (GPDs) of spin-1 particle ρ meson are studied based on a light-front constituent quark model. The form factors and other low-energy observables of the ρ meson are calculated, particularly, the contributions to the form factors and to the GPDs from the valence and non-valence region are explicitly analyzed. Our results for the form factors are compared to the other model calculations[1, 2].

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THE PROTON SIZE PUZZLE: LATEST NEWS

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Current status of the proton size puzzle from experimental and theoretical points of view is briefly discussed. The interest to these studies is primarily related to experiments conducted by the CREMA collaboration (Charge Radius Experiments with Muonic Atoms) with muonic hydrogen and deuterium by methods of laser spectroscopy. As a result a more accurate value of the proton charge radius was found to be $r_p = 0.84184(67)$ fm, which is different from the value recommended by CODATA for 7σ.

Then, we discuss recent calculations of the contribution of light pseudoscalar (PS) and axial-vector (AV) mesons to the interaction operator of a muon and a proton in muonic hydrogen atom, with the coupling of mesons to the muon being via two-photon intermediate state. Numerical estimates of the contributions to the hyperfine structure of the spectrum of the S and P levels are presented. It is shown that such contribution to the hyperfine splitting in muonic hydrogen is rather important for a comparison with precise experimental data.

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ION ACOUSTIC CNOIDAL WAVES IN ELECTRON-POSITRON-ION PLASMAS WITH q-NONEXTENSIVE ELECTRONS AND POSITRONS AND HIGH RELATIVISTIC IONS

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In this work propagation of the nonlinear cnoidal ion-acoustic waves in unmagnetized electron-positron-ion plasma have been studied. The nonextensive distribution function was used to describe plasma electrons and positrons, while plasma ions are taken to be high relativistic. Reductive perturbation method (RPM) was employed to solve the basic equations and derivation of the Korteweg-de Vries equation, which describes the nonlinear fluctuations in such plasma. Characteristic of ion acoustic cnoidal waves in this three component plasma have been studied in details. In this work, we have investigated the effects of relativistic ions and q-nonextensive distribution of electrons and positrons on the characteristics of the ionacoustic periodic (cnoidal) wave, such as the amplitude, wavelength, and frequency.

SEARCH FOR ETA-MESIC NUCLEI IN THE SRC/BM@N EXPERIMENT AT THE NUCLOTRON

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The SRC/BM@N experiment was carried out in the 55th run of the Nuclotron using a liquid hydrogen target and a carbon beam with a kinetic energy of about 3.1 GeV/n.

We propose to analyze the experimental data for the searching of a quasi-bound state of η-meson and nucleons of carbon nucleus in the reaction $p + {}^{12}C \rightarrow {}_{\eta}(A-1) + X \rightarrow \pi + p + (A\text{-}2)$. To achieve this goal, it is necessary to identify a residual nucleus (A-2) and a proton-pion pair formed from η-nuclei decay. We review status of the search for η-mesic nuclei.

EMISSION OF HIGH ENERGY PARTICLES IN HEAVY ION COLLISIONS AND A NON-EQUILIBRIUM EQUATION OF STATE

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To describe the collisions of heavy ions and to find the equation of state of a nuclear matter, it is natural to choose the hydrodynamic approach (see, for example, [1]). The dynamics of heavy ion collisions involves the use of a non-equilibrium equation of state [2, 3, 4] taking into account the effects of nuclear viscosity. This allowed describing energy spectra of protons, pions, and fragments for the collisions of different nuclei at the medium-energy range [3, 4, 5]. However, "high-energy tails " of proton spectra obtained in [6], as it turned out, are not reproduced near the kinematic limit of the spectrum. They turn out more harden when we use a grand canonical ensemble for the distribution function of emitted protons. In this paper, we succeeded to introduce an amendment with account of the microcanonical distribution in the high-energy part of the spectrum to reproduce experimental data [6] without breaking the agreement with other data. In addition, we succeeded to reproduce the high-momentum proton distributions in the reaction $^{12}C+^{9}Be \rightarrow p + X$ at the ^{12}C ion energy of 300, 600, 950 and 2000 MeV/nucleon at the angle of 3.5° [7], which are related to the cumulative region and are not quite well described by "molecular dynamics" and other cascade models. The experimental shoulder in the cross section for the production of protons in the cumulative region is reproduced by our calculations, and sometimes by cascade models. Perhaps this may be due to the contribution of the rescattering of pions to the cumulative production of protons, considered earlier in [8].

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SEMI-INCLUSIVE DEEP INELASTIC SCATTERING IN WANDZURA-WILCZEK-TYPE APPROXIMATION[1]

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We present the complete cross-section for the production of unpolarized hadrons in semi-inclusive deep-inelastic scattering up to power-suppressed $\mathcal{O}(1/Q^2)$ terms in the Wandzura–Wilczek-type approximation which consists in systematically assuming that $\bar{q}gq$–terms are much smaller than $\bar{q}q$–correlators. We compute all twist-2 and twist-3 structure functions and the corresponding asymmetries, and discuss the applicability of the Wandzura–Wilczek-type approximations on the basis of available data. We make predictions that can be tested by data from Jefferson Lab, COMPASS, HERMES, and the future Electron-Ion Collider. The results of this paper can be readily used for phenomenology and for event generators, and will help to improve our understanding of the TMD theory beyond leading twist.

[1]The full text (70 pages) published in arXiv:1807.10606 [hep-ph].

MONTE CARLO MODEL NEUTRINO-NUCLEUS INTERACTIONS: PAST, PRESENT AND FUTURE

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Quantum chromodynamics (QCD) is the present-day fundamental theory of the strong interaction. A main direction of insestigations in physivs of elementary particles and nuclear physics is the testing of QCD [1]. QCD predicts that at high energy density there will be a transformation from ordinary nuclear matter to a plasma of free quarks and gluons, the Quark-Gluon Plasma (QGP). In order to gain new understanding of QCD from the interaction of relativistic heavy ions, one needs directly comparable data sets from systems of various sizes, different energies and different experimental probes.

One of the more attractive topics in modern high energy physics is the description of hadronization - the mechanism by which quarks and gluons produced in hard processes form the hadrons that are observed in the final state. This is an non-perturbative process, for which we only have models [2, 3]. The formation time plays an important role in the dynamics of nuclear reactions, e.g. heavy ion collisions, hadron attenuation in DIS off nuclei as measured by HERMES [4].

Lepton-nucleus scattering provides a nontrivial possibility to study space–time evolution of jets inside a nuclear matter [5]. Compared to hadronic probes, the weaker leptonic probe samples the complete nuclear volume. Using QCD-inspired time dependent cross sections for pre-hadrons we introduced [2, 3] a space–time model for propagation and hadronization of quark and gluon jets in nuclear matter in DIS. The aim of this work is to examine a multiproduction process of charged-current deep inelastic ν_μ-NE and ν_μ-emulsion scattering and to estimate quantitatively the value of a formation length. In conclusion, the role of neutrino generators in modern neutrino experiments with nuclear targets will be discussed [5].

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BOUND STATES OF $pd\mu$, $pt\mu$, AND $dt\mu$ MUONIC MOLECULAR IONS IN QUANTUM ELECTRODYNAMICS

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An investigation of the energy spectra of hydrogen muonic molecules is important for muonic catalysis of nuclear fusion reactions [1]. A calculation of fine and hyperfine structure of muonic molecular ions as well as of higher order QED corrections allows us to predict the rates of reactions of their formation and other parameters of the μCF cycle. In this work, the energy spectrum of the bound states of muonic molecules $pt\mu$, $pd\mu$, and $dt\mu$ is calculated on the basis of variational method [2, 3]. In our work we use a stochastic variational method [3] for obtaining energies of a three-particle bound system with high accuracy. The trial wave function of the muonic molecule in this approach has the Gaussian form. Such a choice of the basis makes it possible to calculate the matrix elements of the Hamiltonian analytically. For a direct numerical calculation, a computer code was written in the MATLAB system to solve the many-body problem based on the Schrödinger equation. The program allows not only to find the values of the bound state energy, but also to perform refinement cycles, which improve the accuracy of previously calculated energies. As a result, the numerical energy levels of the ground and excited states of the muonic molecules $pt\mu$, $pd\mu$ and $dt\mu$ were obtained. We also take into account some corrections connected with the vacuum polarization and relativism.

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HEAVY BARYON SPECTROSCOPY

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The talk contains the review of recent results (both experimental and theoretical) in heavy baryon spectroscopy. Last year many new excited states of heavy baryons containing the c-quark were observed. The outstanding result is the first observation of the doubly heavy baryon with two c-quarks, namely Ξ_{cc} , by the LHCb collaboration. The masses of all newly observed heavy baryons were predicted within the simple quark-diquark picture with either heavy or light diquarks in good agreement with experimental data.

ANALYSIS OF EXPERIMENTAL DATA MEASURED BY BM@N DRIFT CHAMBERS

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The current status of the analysis of experimental data measured by the drift chambers in the BM@N experiment is presented. Apart from the previously published analysis based on the pure beam data, this study shows also the results for the light nuclei collisisions at Nuclotron energies. Some practical issues, such as a removal of the combinatorial backround, estimation of hit coordinates errors and efficiency of the employed track reconstruction algorithm are discussed as well.

ENERGY AND SYSTEM SIZE DEPENDENCE OF MULTI-PARTICLE PRODUCTION IN pp, p-Pb, Xe-Xe AND Pb-Pb COLLISIONS IN ALICE AT THE LHC

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An overview of recent studies by ALICE on energy and system size dependence of multi-particle production in pp, p-Pb and A-A collisions at various LHC energies is presented. It includes, in particular, investigations of unexpected signals of collectivity observed in collisions of small systems like the elliptic flow of electrons from heavy flavor decays in p-Pb collisions and the increase of the production yields of multply strange baryons in pp collisions with high multiplicity. Results on production of loosely bound states of light nuclei, including exotic states of hyper-nuclei are also reported. Experimental results of multi-particle production are compared to different models and discussed. The current ALICE upgrade program aimed at the precise studies of rare processes of heavy flavour formation in hadron collisions is also touched briefly.

SPIN TRANSPARENCY MODE IN THE NICA COLLIDER

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The NICA collider can operate with polarized light ions in two modes. At the Preferred Spin mode (PS mode) the periodic spin motion along the closed orbit is unique, i.e. the static magnetic lattice determines a single stable orientation of the beam polarization at any collider's place. At the Spin Transparency mode (ST mode) any spin direction repeats every particle turn along the closed orbit, i.e. the collider's magnetic lattice is transparent to the spin. ST mode allows one to revise the concept of carrying out experiments with polarized ions at a new precision level. The features of ion polarization control in the ST mode are discussed. The updated schemes of polarization control in the NICA collider providing the ST mode are presented.

EXPLORING THE RELATIVISTIC BOUND STATE STRUCTURE IN MINKOWSKI SPACE: APPLICATIONS TO HADRONS

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In this talk I will review the recent collaborative efforts to solve the Bethe-Salpeter (BS) equation directly in Minkowski space and the application to study the pion, using the Nakanishi integral representation [1], and projection to the light-front introduced in Ref. [2]. This method gives the valence wave function as well as the full BS amplitude, necessary to compute observables in a covariant form, without the limitation of the truncation in the light-front Fock space. The solution of the integral equation relies on the uniqueness of the weight function of the integral representation of the BS amplitude. Numerical solutions of the BS equation beyond the ladder, namely including the cross-ladder was done [3], as well as application to two fermion problem [4].

The generalization to the scattering case was done in [5], and results for the zero energy two-boson scattering case for the ladder kernel were obtaining in [6], relying on the uniqueness of the weight function, which was previously tested numerically in [7] for the ground state. Beyond that the method works for the excited states [8], where also the impact parameter structure of the valence component of the bound state was studied in detail, by transforming analytically the integral form of the valence wave function written in terms of the Nakanishi weight function. The structure of the two boson bound state beyond the ladder kernel was studied through the electromagnetic form factor including the contribution of the irreducible two-body current from gauging the cross-ladder kernel [9]. In addition, some first studies exploring the analytic structure of the BS amplitude in the complex k^0 plane will be shown [10].

The numerical inversion of the integral representation for the Euclidean BS amplitude, as well as for the valence wave function, namely the numerical solution of an ill-posed problem, in order to built the Minkowski space BS amplitude was studied in [11], where we also checked the numerical inversion method with observables like the form factor. The conceptual background that our attempt to obtain the weight function is based relies on the uniqueness of the integral representation for non-perturbative amplitudes, while only the perturbative proof of this property was known so far [1].This problem on the non-perturbative level for the bound-state was solved by recognising that the valence wave function is written as a generalized Stieltjes transform, which can be mathematically inverted, putting the bound state equation for the Nakanishi weight function in a new form overpassing the uniqueness problem [12].

The two fermion 0^+ state in the ladder approximation was studied in [13], where the singular contributions to the kernel was dealt with analytically traced back to light-front end-point singularities, in addition the structure of the fermionic bound state was investigated, and further explored in [14]. Applying the formulation to the quark-antiquark system, the structure of the pion can be explored in this framework, and indeed the ladder kernel taking into account the color degree of freedom for $N_c = 3$, is dominant over the non-planar cross-ladder contribution to the kernel, which is suppressed by a relative

factor of $1/(2N_c)$, giving marginal contribution to the bound state [15]. Therefore, the bound state of the quark-antiquark system forming the pion is dominated by the effective one-gluon exchange. We present some preliminary results exploring the pion structure, making use of the solutions of the field theoretical Bethe-Salpeter integral equation in Minkowski space, for the valence probability, decay constant and longitudinal and transverse momentum distribution of the quarks inside the pion [16].

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SIMULATION OF NEUTRON PRODUCTION IN HADRON-NUCLEUS AND NUCLEUS-NUCLEUS INTERACTIONS IN GEANT4

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Studying experimental data obtained at ITEP [1] on neutron production in interactions of protons with various nuclei in the energy range from 747 MeV up to 8.1 GeV, we have found that slow neutron spectra have scaling and asymptotic properties [2]. Particularly, the spectra for various nuclei are similar, and can be approximately described by the function $A^n f(E)$. The spectra approach the asymptotic regime, namely, they weakly depend on the collision energy at momenta of projectile protons larger than 5 – 6 GeV/c. The properties are taken into account in the Geant4 Fritiof (FTF) model. The improved FTF model describes experimental data on spallation neutron production by 1.2 GeV and 1.6 GeV protons on various targets (Fe, Pb) [3] and experimental data on neutron production by 3.0 GeV protons on targets (Al, Fe, Pb) [4] as well as the Geant4 Bertini model. For neutron production in antiproton-nucleus interactions, it was shown that the FTF results are in a satisfactory agreement with experimental data of the LEAR collaboration [5].

The FTF model with the scaling and asymptotic properties gives promising results for neutron production in nucleus - nucleus interactions at projectile energy 1 – 2 GeV per nucleon [6]. The observed properties allow one to predict neutron yields in the nucleus-nucleus interactions at high and very high energies. Predictions for the NICA/MPD experiment at JINR are presented.

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CHARMONIUM RADIATIVE TRANSITIONS, MESON AND GLUEBALL PARTICLE PROPERTIES WITH THE EFFECTIVE STRONG COUPLING

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Radiative transitions of charmonium excited states χ_{cJ} (J = 0, 1, 2), the particle properties of conventional mesons and scalar glueball are studied by taking into account the mass dependence of the strong coupling in the framework of a QCD-inspired relativistic model with infrared confinement [1,2].

A specific behaviour of the mass-dependent strong coupling with a new infrared freezing point $\alpha_s(0) = 1.03198$ at origin has been found and the latter does not depend on the confinement scale [3].

The spectrum and leptonic (weak) decay constants of conventional mesons have been calculated in good agreement with the latest experimental data.

New estimates on the scalar glueball mass, its 'radius' and gluon condensate value have been performed [3].

For the charmonium triplet excitations χ_{cJ}, their dominant radiative transitions have been studied and the partial decay widths $\Gamma(\chi_{cJ} \to J/\Psi + \gamma)$ have been estimated with reasonable accuracy.

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FEASIBILITY OF ELLIPTIC FLOW STUDIES AT NICA/MPD

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Anisotropic flow presents a unique insight into heavy ion collision physics. The presented simulation feasibility study reveals the prospects of elliptic flow measurements at the Nuclotron-based Ion Collider Facility (NICA) with the Multi-purpose Detector (MPD). The UrQMD model was used for event generation of Au-Au collisions at energy $\sqrt{s} = 11$ GeV. The full MPD reconstruction simulation chain was used, utilizing a realistic detector simulation with GEANT 4, realistic tracking, particle identification and event-plane reconstruction. Presented are results for differential elliptic flow of charged hadrons and reconstructed Λ-hyperons.

QUARK CORRELATIONS IN THE GROUND- AND EXCITED-NUCLEON STATES VIA THE PHOTO-ABSORPTION SUM RULES

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The account of the dynamical correlations of quarks composing the nucleons is necessary for relevant description of nucleon and nuclear interactions. The present work is devoted to use of the technique of known integral sum rules for the cross-sections and amplitudes of the photo-hadron processes. In particular, a kind of the graphical representation and quantification of the valence quark correlation's characteristics referring to the photo-excitations of the nucleon resonances will be presented.

HADRONIC STRUCTURE OF THE PHOTON

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The most popular manifestation of photon hadronic structure is the Vector Dominance Model (VDM). Photon (real or virtual) can turn into vector meson in the course of time defined by uncertainty principle $\tau = l_c = \frac{2E}{m_V^2}$ where E is the photon energy and l_c is so called coherence length. The transparent and simple way to check the existence of hadronic component in photon are measurements of high energy photons interaction with atomic nuclei [1].
The behavior of the nuclear transparency $A^{eff} = \frac{d\sigma(\gamma A \to V A')}{A d\sigma(\gamma N \to V N)}$ ($V = \rho, \omega, \varphi$ etc. vector mesons; A the target mass number) as a function of the photon energy gives the information on hadronic (resolved) part of photon. It was predicted [2] that A^{eff} for any meson photoproduction should decrease with increasing of primary photon energy E, as a result of interference between the meson direct photoproduction off nuclei and its production in two step process: high energy photon coherently produce vector meson which after multiple scattering produced the observable meson . Such decrease with energy is really seen in experimental data , but it is much slower than predicted by VDM.
At present it is generally accepted that before interaction the high energy photon fluctuates in quark-antiquark pair which then interacts with target if the coherence length is larger than size of the target (proton or nuclei). In talk we consider the changes required by such approach and its similarity and distinction from VDM.
The measurements of vector mesons photoproduction off a set of nuclei using the GlueX, JLAB facilities should give the new and accurate data on A^{eff} in the interval energy $E_\gamma = 5 - 9GeV$ and consequently gives a valuable information on the contribution of hadronic part of photon and can help to explain a long standing discrepancy between experimental data and theory predictions [3].
The another subject of the talk will be the consideration of impact of vector meson polarization on its strong interaction and possibility of extraction of the total cross section of longitudinally polarized vector meson with nucleon $\sigma_L(\omega N)$ from the processes of vector mesons production off nuclear targets by photon and pion beams.
Despite the photoproduction of ρ and ϕ mesons where due to s-channel helicity conservation the produced vector mesons are transversally polarized (helicity $\lambda = \pm 1$), in ω meson photoproduction owing to pion exchange the part of produced ω's have longitudinal polarization ($\lambda = 0$). This allows to extract the total cross section of interaction of longitudinally polarized omega meson with nucleon measuring the difference in absorption of transverse $\sigma_T(\omega N)$ and longitudinally polarized $\sigma_L(\omega N)$ omega mesons.
From this point of view the special interest is connected with recent proposal of COMPASS collaboration to measure vector mesons production by pion and kaon beams in charge exchange processes on different nuclei [4]. In such reactions the main part of produced vector mesons are longitudinally polarized (spin density matrix element relevant to longitudinal polarization $\rho_{00} \approx 0.7$), which allows to measure there absorption with higher precision than in the case of photoproduction off nuclei where $\rho_{00} = 0.2$.

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RELATIVISTIC DENSITY FUNCTIONAL FOR NUCLEAR MATTER

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In the present work, we have mapped the exchange Fock contributions from the Dirac–Hartree–Fock (DHF) approach for nuclear matter onto the direct Hartree terms. This results in the relativistic mean field (RMF) model with the density dependent couplings. The density dependence of the effective coupling constants thus reflects the exchange correlations. The exchange part of an energy density of the linear DHF model in dense matter is evaluated in a parameter-free closed form and, after the rearrangement of the terms, expressed as density functional.

It is shown that the exchange contributions are responsible for an increase of the RMF coupling strengths in comparison with the DHF ones. The density dependence of the mapped Fock terms is, however, rather small, and does not account for the one seen in Dirac–Brueckner–Hartree–Fock (DBHF) calculations or phenomenological analyses.

Therefore, the developed formalism has been extended to the nonlinear DHF approximation with field selfcouplings allowed. The nonlinear self–interactions give essential density dependence of effective couplings that is decoupled from the Fock one. For normal nuclear matter densities just the isoscalar field (σ– and ω–meson exchange) selfinteractions are relevant. The density dependence in isovector field (ρ– and δ–meson exchange) is induced through exchange interactions. For dense matter also the isovector field selfcouplings may be used to model the density dependence.

Thus, this contribution is a step in a direction to formulate the effective nuclear density functional suitable for description of wide class of nuclear phenomena over a broad range of densities including the exotic and superheavy nuclei, as well as the neutron stars.

STUDY OF EXCLUSIVE PROCESSES WITHIN GPD APPROACH

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We study the exclusive meson leptoproduction at large photon virtuality Q^2 [1]. These reactions were analyzed within the handbag approach where amplitudes factorize into hard subprocesses and generalized parton distributions (GPDs). On the basis of this approach we investigate physical observables in meson production.

The essential role of transversity effects were found in pseudoscalar and light vector meson production. These contributions are determined by twist-3 effects and mainly essential at not very high Q^2 [2]. The spin asymmetries In vector meson production, which are sensitive to transversity were studied. We learn what information about GPDs can be obtained from these processes.

The possibility to investigate exclusive mesons production at NICA was studied. It seems that one of the essential reaction might be exclusive J/Ψ production which is dominated by a gluon GPDs. The other important process is the exclusive Drell-Yan production in the proton-proton reaction which is determined by two GPDs [3]. We find that at NICA energies $d\sigma/(dQ^2 dt_1 dt_2) \sim 30-40\text{pb}/\text{GeV}^6$ at small t_1, t_2 and $Q^2 = 5\text{GeV}^2$. This reaction can be studied at NICA and give an additional excess to GPDs.

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ANISOTROPIC FLOW MEASUREMENT FROM NA61/SHINE AND NA49 EXPERIMENTS AT CERN SPS

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The NA61/SHINE experiment at the CERN SPS recently extended its program for the energy scan with Pb ions in the energy range of 13-150*A* GeV/c. In the year 2016 a sample of Pb-Pb collisions at 13 and 30*A* GeV/c was collected by the NA61/SHINE experiment. The NA61/SHINE measurements with Pb ions and the experimental techniques using spectators at the lowest energy available at the SPS are also relevant for the preparation of the Compressed Baryonic Matter (CBM) heavy-ion experiment at the future FAIR facility in Darmstadt.

We present results on directed and elliptic flow measurement in Pb-Pb collisions at 30*A* GeV/c relative to the spectator plane determined with the Projectile Spectator Detector. Also a new analysis of 40*A* GeV/c data collected by the NA49 experiment in the year 2000 using forward spectator calorimeters (VETO and RCAL) are presented. The flow coefficients are reported as a function of rapidity and transverse momentum in different classes of collision centrality. The new results are compared with existing results from previous NA49 analysis and the STAR data at RHIC.

DEVELOPMENT OF NICA/SPD SOFTWARE

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First results of NICA/SPD software development are informed.

CENTRALITY AND REACTION PLANE DETERMINATION AT BM@N BY NEW FORWARD HADRON CALORIMETER

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It is proposed that existing Zero Degree Calorimeter for the BM@N experiment at Nuclotron (JINR) will be replaced by new hadron calorimeter for experiments with heavy ions after Nuclotron upgrade. This calorimeter will consist of modules presently constructed for FHCAL MPD and PSD CBM.
Proposed construction and simulation results for centrality and reaction plane determination for different designs of new calorimeter including calorimeter without beam hole, calorimeter with beam hole and calorimeter with additional scintillator detector inside the beam hole will be discussed.
Simulation results of radiation conditions for these different calorimeter designs at BM@N will be shown.

POINCARÉ-INVARIANT QUARK MODEL OF LIGHT MESONS

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The work is dedicated to the calculation of the integral representation of the leptonic decay constants of hadrons in the framework of Poincaré-invariant quantum mechanics (PiQM): in the course of the work the authors constructed a model, that can be considered as a quantum field model of a finite number of particles without interaction. As a result of the developed model, a scheme for constructing the hadron state vectors, as a bound quark system, with the following calculation of the integral representations of the leptonic decays of pseudoscalar and vector mesons is obtained. A distinctive feature of the work authors note the calculation in point form of PiQM and using the pseudoscalar density constant for numerical calculation of constituent quark masses.

K- MATRIX AND UNITARY MULTICHANNEL BREIT-WIGNER APPROACHES FOR SEVERAL RESONANCES: COMPARISON, ADVANTAGES AND DISADVANTAGES

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The K-matrix method is often used to describe several resonances with the same quantum numbers. Its parameters are considering to represent resonance masses and partial widths but such an argumentation is based only on the comparison with the Breit-Wigner (BW) single resonance expression. It is also unclear how to include background in the K-matrix scheme.

The BW approach gives a parametrization of resonances in terms which have direct experimental meaning. We show that taking into account the interference of BWs allows to construct the unitary *S* matrix for an arbitrary number of resonances and decay channels. A background is also included in the scheme and is shown to be a very important part of an analysis. The method and the provided algorithm can be used for different problems in high-energy and nuclear physics. In the presented examples we give a comparison between the K-matrix and unitary BW-approaches.

CROSS-SECTIONS OF NUCLEAR ISOMERS IN THE INTERACTION OF PROTONS ON THIN THORIUM TARGET

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We present experimental results on proton interaction with thorium nuclei at energies 100 and 600 MeV. The experiment was carried out at the intrinsic beam of JINR Phasotron accelerator.

The samples were placed in an accelerator chamber at a radius corresponding to the energy of protons at a current of 0.3 μA. The dimensions of the beam spot were ΔX=2.5 cm and ΔY=2.6 cm. At irradiation, the foils of ^{232}Th were used with a thickness of 100 microns and a weight of 149.5 mg. The foil area was 1.5 cm^2. The thorium foil was sandwiched between two aluminum foils of 50μm thickness each. The front aluminum foil was used to determine the integral flow of protons falling on the ^{232}Th sample by activation of ^{27}Al to ^{24}Na. The back aluminum foil serving as a collector of spallation products.

After irradiation, the samples moved to the spectroscopic complex YSNAPP-2, which separately measured the spectra of gamma radiation of the foils ^{232}Th and ^{27}Al using the HPGe-detector CANBERRA [1].

The processing of the gamma spectra was carried out using the DEIMOS32 program and a set of scripts. The cross sections of the obtained isotopes were compared with data from the Los Alamos National Laboratory under the program MCNP6 1.0 [2, 3].

As a result for thorium foil it was identified 258 gamma lines that belong to 45 nuclides in case of 100 MeV protons, and 222 gamma lines belong to 55 nuclides in the case of 600 MeV proton beam. For the aluminum collector, it was identified 258 gamma lines that belong to 81 nuclides in case of 100 MeV protons, and 330 gamma lines belong to 119 nuclides in the case of 600 MeV proton beam [4].

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CALCULATION OF NEUTRON LEAKAGE FOR A QUASI-INFINITE URANIUM TARGET BY THE MONTE CARLO METHOD

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Experiments on the study of the neutron spectrum in accelerator systems are of considerable interest. One of parameters in the study of the neutron spectrum is neutron leakage. It occurs as a result of slowing and scattering of neutrons through openings, spacing between rods, lead shielding, a beam entry window, etc.

The calculated results for the 4 GeV deuterons are obtained by the Monte Carlo method using the program code FLUKA.

These studies are performed within the framework of the project "Energy and Transmutation of Radioactive Waste" in cooperation with the Laboratory of High Energy Physics of the Joint Institute for Nuclear Research (Dubna, Russian Federation).

HYPERNUCLEI RECONSTRUCTION AT NICA/MPD

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The main task of the NICA/MPD physics program is a study of the properties of nuclear matter under extreme conditions. One path is true a study of strangeness production in nuclear collisions.The enhance production of strange particles in heavy-ion collision is consider to be signal for quarck-gluon plasma formation.

The MPD detector performance to measure different hypernuclei species in Au+Au collisions at NICA conditions, will be presented.

DECAY $B_s \to K^{*0}\mu^+\mu^-$ IN COVARIANT QUARK MODEL

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This work is devoted to the study of the rare $B_s \to K^{*0}\mu^+\mu^-$ decay. We compute the relevant form factors in the framework of the covariant quark model with infrared confinement in the full kinematical momentum transfer region. The calculated form factors are used to evaluate branching fractions and polarization observables in the $B_s \to K^{*0}\mu^+\mu^-$ decay . We compare the obtained results with available experimental data and the results from other theoretical approaches.

VME–BASED DAQ SYSTEM FOR THE DEUTERON SPIN STRUCTURE SETUP AT THE NUCLOTRON INTERNAL TARGET STATION

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The new powerful VME–based data acquisition (DAQ) system has been designed for the Deuteron Spin Structure setup [1] placed at the Nuclotron Internal Target Station [2]. The DAQ system is built using the netgraph–based data acquisition and processing framework *ngdp* [3, 4]. The software dealing with VME hardware is a set of *netgraph* nodes in form of the loadable kernel modules, so works in the operating system kernel context. The specific for current implementation nodes are described, while specific software utilities for the user context are following.

The *b2r* (binary–to–ROOT) server converts raw data into per trigger and per accelerator spill representations, which are based on C++ classes derived from ROOT framework [5] ones. This approach allows us to generalize code for histograms filling and polarization calculation. The *b2r* optionally stores ROOT events as ROOT `TTree` in file(s) on HDD, so supports the design of some express offline.

The *histGUI* software module provides interactive online access for human operator to histograms filled by the *r2h* (ROOT–to–histograms) server, which obtains the ROOT event representations from *b2r*. The *r2h* supports the calculation and histograming of runtime configurable variables as well as raw data variables, and optionally stores ROOT histograms in file(s) on HDD.

Because the spin studies at Nuclotron requires fast and precise determination of the deuteron and proton beam polarization, the polarization calculator software module is implemented. This calculator based on runtime configurable *r2h* code allows us to compute polarization values online and suitable for integration into the Web–based scheme of the polarimeters representation and control [6, 7].

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HOW TO MEASURE THE LINEAR POLARIZATION OF GLUONS IN UNPOLARIZED PROTON USING THE HEAVY-QUARK PAIR LEPTOPRODUCTION

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We study the azimuthal $\cos\varphi$ and $\cos 2\varphi$ asymmetries and the Callan-Gross ratio $R = \mathrm{d}\sigma_L/\mathrm{d}\sigma_T$ in heavy-quark pair leptoproduction, $lN \to l'Q\bar{Q}X$, as probes of linearly polarized gluons inside unpolarized proton. First, we determine the maximal values for the $\cos\varphi$, $\cos 2\varphi$ and R quantities allowed by the photon-gluon fusion with unpolarized gluons. Then we calculate the contribution of the transverse-momentum dependent gluonic counterpart of the Boer-Mulders function, $h_1^{\perp g}$, describing the linear polarization of gluons inside unpolarized proton. Our analysis shows that the maximum values of the azimuthal distributions and Callan-Gross ratio depend strongly on the gluon polarization. We conclude that the azimuthal $\cos\varphi$ and $\cos 2\varphi$ asymmetries as well as the ratio R in heavy-quark pair leptoproduction are predicted to be large and very sensitive to the contribution of linearly polarized gluons. For this reason, future measurements of these quantities in charm and bottom production at the proposed EIC and LHeC colliders seem to be very promising for determination of the linear polarization of gluons inside unpolarized proton.

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DETERMINATION OF GEOMETRY OF HEAVY ION COLLISIONS WITH FORWARD HADRON CALORIMETER (FHCAL) AT MPD/NICA

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The main purpose of the FHCal is to provide an experimental measurement of a heavy-ion collision centrality (impact parameter) and orientation of its reaction plane. Precise event-by-event estimate of these basic observables is crucial for many physics phenomena studies to be performed with the MPD experiment. FHCal consists of two identical arms placed at the left/right sides from the beam collision point. Due to the fine modular structure and detection of spectators in both forward/backward regions, the angular resolution of the reaction plane reconstruction is below 30 degrees.

Since the heavy fragments escape into beam holes, it is not possible to discriminate the central and peripheral collisions using only the deposited energies in FHCal. The subdivision of the calorimeter into two, inner and outer parts, and the calculation of the energy depositions separately in these calorimeter parts allows the construction of new observable, the energy asymmetry. Taking the two-dimensional correlation between the energy asymmetry and full energy deposition in calorimeter, one would be possible to resolve the ambiguity in the centrality determination.

DP BREAKUP REACTION INVESTIGATION UNDER SPECIFIC KINEMATIC CONFIGURATIONS AT ITS OF NUCLOTRON

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Spin structure of the np SRCs has been investigated via the measurements of the tensor analyzing power A_{yy} in deuteron inclusive breakup at JINR. Data analysis has been performed at various energies in the wide regions of the longitudinal x_F and transverse proton momentum p_T [1]. The A_{yy} data demonstrate the dependence on at least these two internal variables, but used approach [2] failed describe the data. In the vicinity of the Sagara discrepancy the currently known 3NFs contribute by up to 30% for dp breakup reaction measured at KVI at energy of 130 MeV [3]. 3NFs improve the description of a part of the data but breaks other. It was found that relativistic effects contribution is located mainly at backward angles in the nd elastic scattering cross section at 70 MeV and 250 MeV [4], but theirs contribution is not large enough to fill discrepancy between experimental data and theory, even in the case when standard three nucleon forces [5] are used. For the d(n,np)n breakup reaction at 200 MeV large relativistic effects were observed in configuration where one arm is fixed and second arm scans the angular range. The contribution which comes from relativistic effects can reach up to 60%. Dp breakup reaction is investigated under specific kinematic configurations (space star, coplanar star, ...) at Nuclotron. The purpose of study is to investigate possible 3NFs and relativistc effects in specific configuration using unpolarized and polarized deuteron beam at energy between 300 MeV – 500 MeV.

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STUDY OF MULTIPION PRODUCTION IN NP-INTERACTION AT INTERMEDIATE ENERGIES

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The reactions of the multipion production in np-interactions were studied at the momenta of incident neutrons from 1.73 to 5.20 GeV/c. The pions multiplicity of the studied reactions was from 2 to 6. It was shown that the characteristics of the reactions were satisfactory described within the framework of OPER-model (One Pion Reggeized Exchange). Additionally the diagrams of one baryon exchange (OBE) were used for the better description of the data at the momenta of incident neutrons below 3 GeV/c.

NEUTRINO PROPAGATOR IN MEDIA: SPIN PROPERTIES AND SPECTRAL REPRESENTATION

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When neutrino propagates through the media (dense matter or magnetic field), it modifies a standard picture of flavour oscillations [1, 2, 3] and further studying needs to use methods of quantum field theory.

We build a spectral representation of neutrino propagator in matter moving with constant velocity or in constant homogenious magnetic field. In this representation based on the eigenvalue problem a propagator looks as a sum of single poles, accompanied by orthogonal matrix projectors. A spectral representation was discussed earlier for dressed fermion propagator in theory with parity violation [4] and for matrix propagator with mixing of few fermionic fields [5].

To construct a spectral representation for inverse propagator one should solve the eigenvalue problem for inverse propagator S . If the eigenprojectors set Π_i is the complete orthogonal system, then neutrino propagator G in matter or magnetic field looks like

$$G = \sum_{i=1}^{4} \frac{1}{\lambda_i} \Pi_i. \tag{1}$$

In both cases there exists definite 4-axis z of complete polarization, such that corresponding spin projectos commute with propagator (but not always commute with Hamiltonian). As a result, all eigenvalues of propagator (and, consequently, dispersion laws) are classified accoding to spin projection on this axis. The found generalized spin projectors play a special role in the eigenvalue problem, simplifying essentially algebraic calculations and reducing algebraic problem to the vacuum case.

Here we consider the case of one neutrino flavor but the most interesting application of this approach is related with neutrino oscillation in media. The presence of discovered axis of complete polarization will play essential role in QFT description of this phenomenon.

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BOUND STATES OF PURELY RELATIVISTIC NATURE

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Bethe-Salpeter (BS) equation [1] for two scalar particles interacting by massless exchange reproduces, with relativistic corrections, the spectrum given by the Schrödinger equation with the Coulombien potential (Balmer series). In 1954 Wick [2] and Cutkosky [3] found that the BS equation, in addition to the Balmer series, provides another infinite series. The latter appears if the fine structure constant is enough large: $\alpha > \frac{\pi}{4}$. Whereas the energy levels of the Balmer series tend to zero when $\alpha \to 0$, the levels of this another series tend to zero when $\alpha \to \frac{\pi}{4}$. This series has no any non-relativistic counterpart. Therefore, the corresponding solutions were called in [2, 3] "abnormal". There was a discussion, whether these solutions are the physical ones, or they indicate on a flaw of the BS equation.

The value $\alpha > \frac{\pi}{4}$ corresponds to a point-like nucleus with $Z > 107$. We consider more realistic case of massive exchange, when the coupling constant of strong interaction can be indeed enough large. We ask: whether do the abnormal states exist for massive exchange? Solving the BS equation, we find that they still exist. However, the abnormal states differ from the normal ones by their behavior in the nonrelativistic limit, when speed of light c, taken as a formal parameter, tends to infinity. Then the energies of the "normal" states tend to constant values, given by the Schrödinger equation, whereas the energies of the abnormal states tend to zero and for enough large c disappear, like the energy levels in a potential well disappear when depth of the well decreases.

We conclude that the relativistic BS equation has more rich spectrum than the Schrödinger one. It predicts existence of additional levels, having purely relativistic origin, like the Dirac equation predicts anti-particles.

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THE $^1S_0$ np WAVE FUNCTION FROM THE $n + p \to d + \gamma$ PROCESS

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There is a well-known assumption that thermal np capture and deuteron electrodisintegration near threshold provide convincing evidence for the pion exchange currents in the two-nucleon electromagnetic reactions [1]. We dispute this point of view and show that the part played by the meson exchange currents in the low energy $n + p \to d + \gamma$ reaction may be simulated by properly fitted local $^3SD_1$ and $^1S_0$ np partial potentials that describe the NN elastic scattering by construction as well as deuteron electromagnetic form factors.

The formalism for the $n + p \to d + \gamma$ cross section calculation at the threshold is described in [1]. Results of our calculations for different realistic np potentials (referenced as in [3]) are shown in Table 1. We see that it is quite possible to describe the low energy $n + p \to d + \gamma$ reaction by a properly fitted local $^1S_0$ np partial potential that describes also the NN elastic scattering up to 2.7 GeV by construction (Moscow14 potential [2]). Moreover it seems possible to describe also all available eD elastic scattering data with fitted realistic $^3SD_1$ deuteron waves and with $^1S_0$ wave stemming from an np local potential and fitted simultaneously to the NN elastic scattering up to 2.7 GeV and to $n+p \to d+\gamma$ data (Moscow17-eD Inverse potential [3]).

Table 1: Cross sections of the neutron capture process $n + p \to D + \gamma$ calculated with different realistic deuteron and NN scattering wave functions.

	a_s, Fm	$\sigma(np \to D\gamma$, mb
Exp	-23.7	334.2 ± 0.5
NijmII	-23.6	304
Idaho	-23.7	308
Paris	-17.5	188
JISP16	-22.4	286
Moscow14	-23.7	334
Moscow17-eD Inverse	-23.7	334

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ESTIMATION OF PION EMISSION SOURCE IN SYMMETRIC AND ASYMMETRIC COLLISIONS USING THE URQMD MODEL

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The femtoscopy tehnique allows one to measure the spatial and temporal characteristics of the particle emission source produced at high energy collisions. In non-central ultra-relativistic heavy ions collisions emission source may be tilted in the reaction plane. The orientation of freeze-out distributions is interesting because it provide complementary information about emission source. In the experiment this information is extracted by measuring pion femtoscopy radii as a function of the pair angle with respect to the first order reaction plane.

In this talk, we will present the behavior of the pion emission source at 200 GeV in symmetric (Au+Au) and asymmetric (d+Au, ^{3}He+Au and Cu+Au) collisions estimated using the UrQMD model.

COMPARISON OF THE RESULTS OF IRRADIATION OF THE ^{237}Np SAMPLE IN THE «QUINTA» SECONDARY NEUTRON FIELD AND IN THE DIRECT PROTON BEAM

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The experiments were carried out within the framework of the project "Energy and Transmutation of Radioactive Waste" and aimed at solving the problem of the transmutation of actinides.

The aim of this paper is to compare the cross sections for the capture and fission reactions at different radii of the «Quinta» setup and to determine their ratio [1,2] for the residual nuclei in the ^{237}Np sample.

Fig.1 shows a comparison of gfrom axis).

As ^{exp}ected, under the influence of a direct proto = 0) and in the field of secondary neutrons on the surface of uranium target «Quinta» ("B",
R = 200 mm from axis).

As expected, under the influence of a direct proton beam with an energy of 660 MeV, fragmentation is more characteristic ("A"-gamma lines: ^{92}Y - 934 keV, ^{91}Sr - 1024 keV, ^{118m}Sb - 1050 keV, ^{117m}Cd - 1065 keV) see fig.1, while in the field of low-energy neutrons a significant fraction of the reactions are due to neutron capture ^{237}Np, with the formation of the ^{238}Np and the subsequent beta decay into ^{238}Pu ("B"-gamma lines: ^{238}Np - 985, 1026 and 1029 keV).

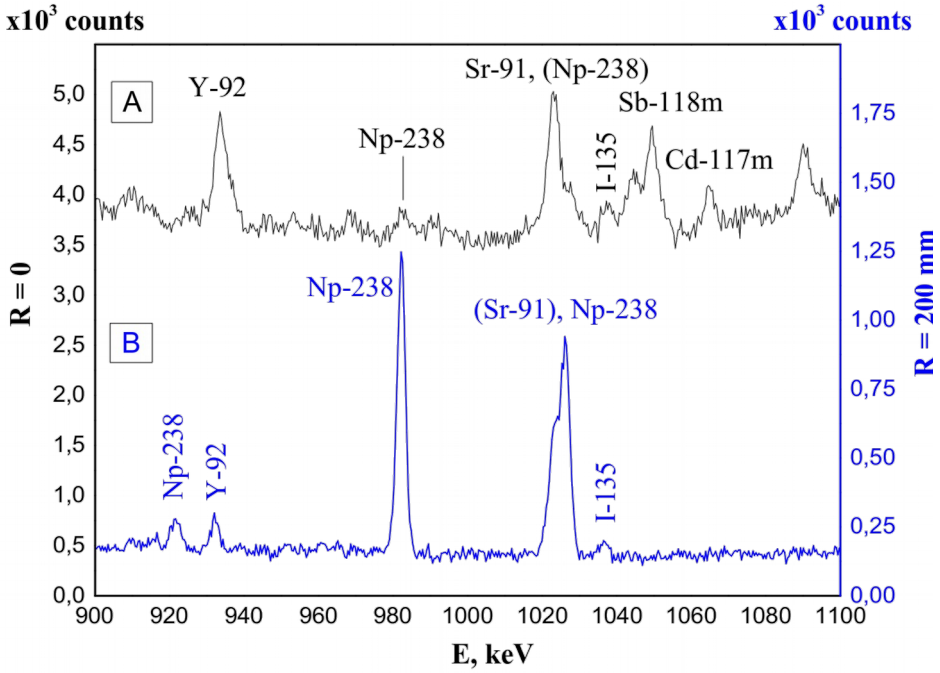

Fig.1. Gamma spectra of ^{237}Np after irradiation: "A" – by proton beam; "B" – by neutron field.

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NEW RESULTS OF THE CLUSTERS AND HYPERNUCLEI FORMATION WITHIN PHQMD MODEL

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We present a new results on the dynamical modelling of cluster formation with the new combined PHQMD+FRIGA model at Nuclotron and NICA energies. The FRIGA clusterisation algorithm, which can be applied to the n-body transport approaches, is based on the simulated annealing technique to obtain the most bound configuration of fragments and nucleons. The PHQMD+FRIGA model is able to predict isotope yields as well as hyper-nucleus production.

Based on present predictions of the combined model we study the possibility to detect such clusters and hypernuclei in the BM@N and MPD/NICA detectors.

HADRONIC RESONANCE PRODUCTION WITH ALICE AT THE LHC

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Hadronic resonance production plays an important role both in elementary and in heavy-ion collisions. In heavy-ion collisions, since the lifetimes of short-lived resonances are comparable with the lifetime of the late hadronic phase, regeneration and rescattering effects become important and resonance ratios to longer lived particles can be used to estimate the time interval between the chemical and kinetic freeze-out. The measurements in pp and p-Pb collisions constitute a reference for nuclear collisions and provide information for tuning event generators inspired by Quantum Chromodynamics. In this talk, we present recent results on short-lived hadronic resonances obtained by the ALICE experiment at the LHC energies, including first results from the Xe-Xe run. The ALICE results on transverse momentum spectra, yields and their ratio to long-lived particles, and nuclear modification factors will be discussed. The results will be compared with model predictions and measurements at lower energies.

A LOOK AT HADRONIZATION VIA HIGH MULTIPLICITY

E. Kokoulina, A. Kutov, V. Nikitin, V. Riadovikov, A. Vorobiev

Multiparticle production is studied experimentally and theoretically in QCD that describes interactions in the language of quarks and gluons. In the experiment the real hadrons are registered. For transfer from quarks and gluons to observed hadrons various phenomenological models are used.

In order to describe the high multiplicity region, we have developed a gluon dominance model (GDM). It represents a convolution of two stages. First stage is described as a part of QCD. For second one (hadronisation), the phenomenological model is used. To describe hadronisation, a scheme has been proposed, consistent with experimental data in the region of its dominance. Comparison of this model with data on e^+e^- annihilation over a wide energy interval (up to 200 GeV) confirms the fragmentation mechanism of hadronisation, the development of the quark-gluon cascade with energy increase and domination of bremsstrahlung gluons.

The description of topological cross sections in *pp* collisions within of GDM testifies that in hadron collisions the mechanism of hadronisation is being replaced by the recombination one. At that point, gluons play an active role in the multiparticle production process, and valence quarks are passive. They stay in the leading particles, and only the gluon splitting is responsible for the region of high multiplicity.

GDM with inclusion of intermediate quark charged topologies describes topological cross sections in a proton-antiptoton annihilation and explains linear growth of a secondary correlative momentum in the negative area.

The scaled variance of a neutral pion number mesuared by us is rising abruptly in the region of high total multiplicity and differs from Monte Carlo predictions by seven standard deviations. The growth of fluctuations of the neutral pion number in this region may indicate the formation of a pion (Bose-Einstein) condensate. While searching for this collective phenomenon, events with a predominance of a large number of neutrals (16) among total multiplicity (32) have been found along with an indication that “centaurs” exist. Despite the growth of fluctuations on the neutral number, their average remains equal to 1/3 of the total pion number.

Our future study of soft photon yield in the region of high multiplicity at U-70 and Nuclotron is presented.

MODELING THE INFLUENCE OF HEAVY ION BEAMS ON THE NEUROGENESIS AND THE FUNCTIONING OF HIPPOCAMPAL NEURAL NETWORKS

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Radiation-induced cognitive disfunction becomes a serious concern in hadron beam therapy and long-term manned space flights. In recent years a number of neurocognitive detriments have been reported, including progressive deficits in short- and long-term memory loss, spatial orientation, visual motor processing and impaired learning. The analysis of recent experimental studies at particle accelerators with energetic protons and heavy ions suggests that the hippocampus is one of the most sensitive regions of the central nervous system (CNS) under irradiation. The sub-granular zone of hippocampus contains radio-sensitive population of dividing cells participating in neurogenesis, therefore detailed study of related phenomena is very important task. However, in order to predict any cognitive dysfunction the exisiting models of neurogenesis need to be supplemented with functional models of neural networks reflecting the actual performance of neural cells in the process of cognition. This was the goal of present study.

We have used well-known computational models of hippocampal neurogenesis and applied them in simulation of the dynamics of neural networks after the incident irradiation of protons and heavy ion beams of different energies and doses. Kinetic equations describing neuron population were solved numerically in Wolfram Mathematica, and neural networks were simulated using NEURON toolkit. Neuron death and suppression of neurogenesis caused by irradiation lead to depression of network activity. Moreover, modification of network topology caused by changed ratio between mature and immature neurons and/or between neurons of different morphology results in much complex alterations of network activity. Comparison of computed action potential spike rasterograms and EEG signals with their analogs corresponding to known pathologies of CNS could provide better understanding of radiation-induced effects of accelerated charged particles.

FEASIBILITY OF MEASURING EDM IN SPIN TRANSPARENT COLLIDERS

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A new polarization control mode called a Spin Transparency (ST) mode is currently being actively developed for new facilities. The ST mode is an intrinsic feature of figure-8 magnetic ring configuration such as the JLEIC collider at Jefferson Lab. A racetrack configuration can be converted to the ST mode by inserting two identical Siberian snakes into its opposite straights as in NICA, JINR. To detect the direct effect of the electric dipole moment on the spin, one must ensure the spin transparency of the magnetic dipole moment, the MDM Spin Transparency. The MDM Spin Transparency means that, when neglecting the particle's EDM, the effect of all fields along the accelerator orbit on the spin is reduced to zero. For colliders in the ST mode, in the absence of electric fields, the MDM Spin Transparency condition is automatically satisfied for any beam momentum. To measure the EDM, one must introduce additional electric fields into a collider such that they, on one hand, do not violate the MDM transparency condition and, on the other hand, maximize the effect of the EDM on the spin. The ST mode is applicable to measuring the EDMs of both protons and deuterons. We describe an experimental setup and provide estimates of the limiting EDM values that can be measured in the JLEIC and NICA facilities.

PHYSICS ARCHITECTURE. PART TWO

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The talk is devoted to the jubilee of academician M.A.Markov, who was born in 1908. Now we have also 100th anniversary of the gauge invariance principle proposed by Weyl in 1918. During the period from 1967 to 1988 M.A.Markov was academician secretary of AN USSR Nuclear Department. He organized the line of conferences dedicated to actual problems of theoretical, nuclear and elementary particle physics. One of them was international seminar "Vector mesons and electromagnetic interactions" under A.M.Baldin direct leadership. It went off in JINR in September of 1969. Just that seminar gave birth to the conferences line named "Baldin autumn". The discussions at the A.M.Baldin seminar were subsequently very useful for many critical situations in theoretical and experimental physics.

The first of plenary session of the seminar included L.D. Faddeev talk about gauge field quantization, which cleared the way to construction of renormalized quantum gauge field theory. My talk was dedicated to the transformation of the classical gauge field theory into geometrical one. As a result the unified geometrical theory was obtained, which could include any interactions together with Einsteinian gravity. In this connection both formulations of Weyl's local gauge invariance principle (of 1918 and 1929) as well as Einsteinian principle of general relativity were used. This approach was based on the fibre bundle geometry, which was created by mathematicians at that time. This theory makes realizable classification of interactions in accordace with the local Lie's symmetry groups associated with them. Such approach leads to the VIIth Hilbert's problem solution.

To obtain further development of the gauge field theory it is necessary to decide the question of the gauge field mass origin. It is key moment both in quantum and in geometrical classical theories of the gauge fields. Therefore it is very important to analyse the experiments, which massive and massless particles are converted in each other in (similar Baldin experiments in JINR in 1967).

STUDY OF PRODUCTION OF FOUR CHARGED PIONS WITH CMD-3 DETECTOR AT VEPP-2000 COLLIDER

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Since 2010 the VEPP-2000 electron-positron collider has been operated at Budker Institute of Nuclear Physics in the center-of-mass (c.m.) energy range from $\sqrt{s} = 320$ MeV to 2000 MeV [1]. VEPP-2000 has two interaction regions in which the Cryogenic Magnetic Detector (CMD-3) [2] and the Spherical Neutral Detector (SND) [3] are installed.

Production of four charged pions in e^+e^- annihilation has been studied before with good statistics at the CMD-2 [5] and SND detectors [6] as well as using initial-state radiation (ISR) with BaBar [7] at which a low systematic uncertainty of about 3% was achieved for the $e^+e^- \to \pi^+\pi^-\pi^+\pi^-$ cross section in the wide c.m. energy range. Earlier experiments are discussed in [8].

In this work the cross section of the process $e^+e^- \to \pi^+\pi^-\pi^+\pi^-$ has been measured using an integrated luminosity of 17 pb^{-1} collected with the CMD-3 detector in the c.m. energy range 650-1000 MeV. Also studied are the internal dynamics of four-pion production. High-precision measurements of various hadronic cross sections are of great interest in relation with the problem of the muon anomalous magnetic moment g-2. The $e^+e^- \to \pi^+\pi^-\pi^+\pi^-$ cross section can be also used to test relations between e^+e^- annihilation and τ lepton decays based on conservation of vector current.

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RESOLVING THE SELEX-LHCB DOUBLE-CHARM BARYON CONFLICT: THE IMPACT OF INTRINSIC HEAVY-QUARK HADROPRODUCTION AND SUPERSYMMETRIC LIGHT-FRONT HOLOGRAPHIC QCD

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Double charm baryons is a rigorous prediction of Quantum Chromodynamics. The first experimental evidence for the existence of double-charm baryons was published by the SELEX collaboration more than 15 years ago [1, 2]. The past two years the LHCb collaboration provided high statistics observation of double charm baryons [3, 4]. However, the mass difference between the $\Xi_{cc}^{+}(ccd)$ candidate reported by SELEX and the $\Xi_{cc}^{++}(ccu)$ candidate reported by LHCb was 103 MeV/c^2, so these states cannot be readily interpreted as an isospin doublet since one would expect a mass difference of isospin partners to differ by only a few MeV/c^2.

In the talk we show that the intrinsic heavy-quark QCD mechanism for the hadroproduction of heavy hadrons at large Feyman-x can resolve the apparent conflict between measurements of double-charm baryons by the SELEX fixed-target experiment and the LHCb experiment at the LHC collider. We show that in fact both experiments are compatible, and that both can be correct [5, 6]. The observed spectroscopy of double-charm hadrons is in agreement with the predictions of supersymmetric light front holographic QCD [6, 7].

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STRUCTURE OF THE MAJORANA EQUATION AND ITS PHYSICAL INTERPRETATION

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It is generally accepted that the Mayorana article (1937) describes, particles that do not have antiparticles. Accurate analysis showed that this article raises questions that were not answered after decades up to our days. It turned out that there is the ability to clearly delineate what kind of equations can describe neutral leptons. In our article it is shown that it is not the Dirac equation. We shall call the Majorana equation an equation that describes stable, massive, and neutral leptons. Fulfillment of the three requirements listed above leads strictly and unambiguously to the corollary: Majorana equation describes a pair of stable, massive, neutral leptons — particle and antiparticle. This situation is similar to the Dirac equation, however, the spin properties of leptons of this type differ from spin properties of an electron or a positron.

COHERENT DIBARYONS

B.F. Kostenko

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It is shown that independent experiments of Yu. A. Troyan and V.S. Stavinsky, which were set out in [1-3] and discussed in [4], might reveal in concord unusual dibaryons that are the quantum-mechanical superposition of the conventional mass-fixed light dibaryons. Mathematically, such objects are usual or generalized coherent states of 2-D quantum oscillator excited by the momentum transfer in N-N collisions. As a probable physical interpretation of these states, low-energy excitations of the constituent quarks inside 6-q systems may be considered. A transverse momentum anomaly found out in a paper [5] in data [6,7] obtained by the EVA collaboration can also be explained in terms of the coherent dibaryons and may be a sign of another characteristic property of the coherent states under discussion – a good localizability of the quark motion in the usual 3-D space.

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EMC EFFECT AT SMALL BJORKEN X VALUES

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The Bessel-inspired behavior of parton densities at small Bjorken x values, obtained in the case of the flat initial conditions for DGLAP evolution equations, is used [1] along with frozen and analytic modifications of the strong coupling constant to study the so-called EMC effect. Among other results, this approach allowed predicting small x behavior of the gluon density in nuclei.

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STATUS OF NICA-SPIN PROGRAM

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The first goal of the NICA project is a study of hot and dense strongly interacting matter in heavy ion collisions. The center-of-mass energy of the facility in this mode is limited to $\sqrt{s_{NN}} = 11$ GeV. Spin physics research with extracted and colliding polarized proton beams can be performed over energy range from 0.5 to 12.5 GeV at fixed target mode and from 2 to 27 GeV at head-on collision mode. Beam of polarized deuterons is available at the Nuclotron also.

Preparation of the research program at the Nuclotron and the future NICA collider facility is carried out during the last years. The design, construction and tests of new polarized ion source (protons and deuterons), reconstruction of the existing linac LU-20, development of polarimetry and the spin control systems are current works carried out in the Laboratory.

The NICA-SPIN program foresees that the SPD detector will be constructed and installed in the IP-2 of to study spin physics. There is a number of processes which could be studied with this detector and with the fixed target detectors at beams extracted from the upgraded Nuclotron, namely: DY processes with longitudinally and transversally polarized p and d beams; extraction of unknown (poorly known) parton distribution functions (PDF); PDFs from J/ψ production processes; spin effects in various exclusive and inclusive reactions; cross sections of diffractive processes; helicity amplitudes and double spin asymmetries in elastic reactions and other effects.

The NICA-SPIN program is considered also within the frames of a long term future scientific program of JINR. Possibilities of the EDM search experiments at the collider are discussed, in particular.

The results obtained in 2016-2018 are presented and discussed in the report.

STRONGLY INTENSIVE FLUCTUATIONS AND CORRELATIONS IN ULTRARELATIVISTIC NUCLEAR COLLISIONS IN THE MODEL WITH STRING FUSION

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The exploration of the QCD phase diagram and a search for the critical point is one of the main subjects of heavy ion physics. The experimental investigation of the phase diagram of a strongly interacting matter is related to the study of the fluctuations and correlations of observables in the nuclear collisions at high energy. Around the critical point, anomalies, such as enhanced fluctuations are expected to appear.

In the present work, the string-parton Monte Carlo model is applied to to the relativistic nuclear collisions at high energy. The model includes the string fusion effects and the finite rapidity length of strings, and also charge conservation in string fragmentation. We calculated several types of strongly intensive event-by-event variables and long-range correlations for the experiment.

The research was supported by the grant of the Russian Foundation for Basic Research (project 18-32-01055 mol_a).

HUNTING FOR QCD STRINGS IN e^+e^--ANNIHILATION

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We develop new mathematical tool to study the non-perturbative QCD effects in low-energy processes using the ordinary and the analytic perturbation theory. We apply this tool to extract the lowest dimensional condensates from the high-precision fits data on e^+e^--annihilation to isovector pion channels. We are searching for the operator with dimension 2. Our consideration is based on the Borel transform of the Adler function corresponding to e^+e^--annihilation into pions. It is shown that within the framework of the proposed method the C_2 coefficient of dimension 2 operator is negative and is more close to zero for the analytical perturbation theory, which may therefore be partially responsible for short strings effect.

CHIRAL SYMMETRY RESTORATION AND MIXING THEOREMS IN HADRON MATTER

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I consider the phenomena of chiral symmetry restoration in dense hadron matter. The constraints imposed by chiral symmetry on hadron correlation functions in dense medium are discussed. It is shown that these constraints imply a certain structure for the in-medium hadron correlators and lead to the mixing theorems between chiral partners, similar to those considered by Day, Eletsky and Ioffe at finite temperature. The effect of mixing of the chiral partners correlation functions arises from the interaction of nuclear pions with corresponding interpolating currents. It reflects the phenomena of partial restoration of chiral symmetry. The different scenarios of such restoration are briefly discussed. Both 2-point and 3-point functions are considered.

1S-2S ENERGY SHIFT IN MUONIC HYDROGEN

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The current experimental program for the study of fine and hyperfine structure of simplest muonic atoms is successfully implemented, starting with 2010, when transitions $(2S^{F=1}_{1/2} - 2P^{F=2}_{3/2})$ and $(2S^{F=0}_{1/2} - 2P^{F=1}_{3/2})$ were measured in muonic hydrogen [1]. The experiments with muonic hydrogen have shown that there is significant discrepancy between the values of charge radii of the proton and deuteron obtained from experiments with electronic and muonic atoms (proton radius puzzle). The nature of this discrepancy is still unknown, so precise calculation of different energy intervals is an actual problem, e.g. [2].

One of the planned tasks of the CREMA collaboration is the measurement of the $(1S - 2S)$ transition frequency in muonic hydrogen. It requires an appropriate precise theoretical study. It is useful to note that in the case of a hydrogen atom the interval of a large fine structure $(1S - 2S)$ was measured with very high accuracy. The main goal of our calculation is to increase the accuracy of the previous theoretical results by taking into account new contributions. Our approach to the calculation of the $(1S - 2S)$ shift in muonic hydrogen is based on the quasipotential method in quantum electrodynamics [3]. Calculating $(1S-2S)$ fine structure interval with an accuracy 0.0001 meV, the terms of the Hamiltonian that contribute to the given transition of orders $\alpha^4, \alpha^5, \alpha^6$ are constructed. These contributions are determined by the effects of nuclear structure, recoil, one-, two- and three-loop vacuum polarization and relativistic corrections. The obtained complete result for $(1S - 2S)$ interval in muonic hydrogen can be used for a comparison with the future experimental data of the CREMA collaboration and extraction new value of the proton and deuteron charge radii.

The work is supported by RSF (grant 18-12-00128).

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^{241}Am INCINERATION MEASUREMENTS WITH ACTIVATION METHOD IN THE «QUINTA» NEUTRON FIELD

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The experiments were carried out within the framework of the project "Energy and Transmutation of Radioactive waste" and aimed at solving the problem of the transmutation of actinides. The experiment has been performed on a «Quinta» uranium (^{238}U) assembly that generates a neutron field under the action of beams from the JINR Nuclotron and Phasotron.

Gamma spectra of the irradiated targets were measured at HPGe detector. The exposures for measurements of gamma spectra Am-241 were from 3 minutes to 10 hours. The gamma spectrum of the Am-241 sample is shown in Fig.1 (at the exposure of 3 min).

During the study of the spectrum of the irradiated sample Am-241, the following nuclei were identified: ^{132}I (668 keV, 718 keV); ^{133}I (530 keV); ^{134}I (847 keV, 884 keV, 1072 keV); ^{135}I (1132 keV, 1260 keV); ^{91}Sr (555 keV, 1024 keV); ^{92}Sr (1383 keV); ^{97}Zr (658 keV, 743 keV); ^{138}Cs (1435 keV).

For these nuclei, the fission reaction rates were determined in the energy range from 100 to 1500 keV and the average value was obtained:

$I_{fission} = (9.48 \pm 3.53) \times 10^{-6}$ fissions/g/proton – preliminary fission rate.

Determination of neutron capture rate is difficult, since the gamma radiation intensity of neutron capture products of ^{241}Am is small.

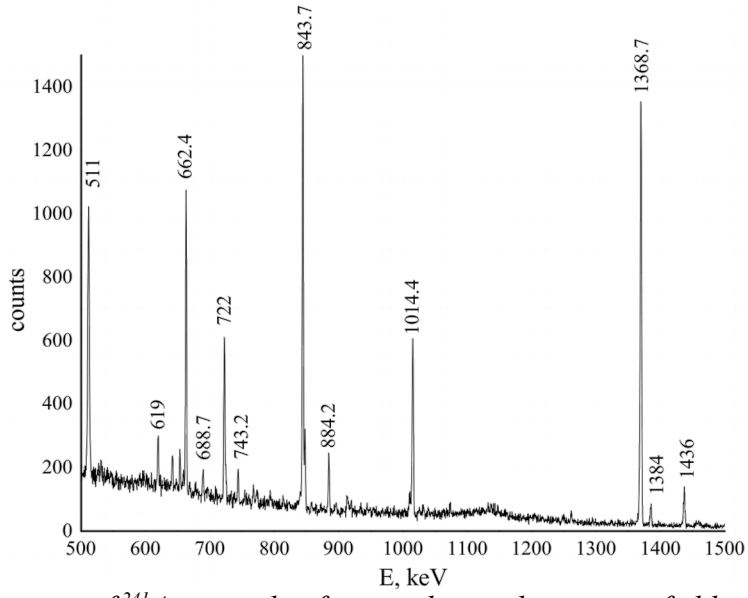

Fig.1. Gamma spectrum of ^{241}Am sample after irradiation by neutron field of «Quinta» setup (at the measurement exposure - 3 min).

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OVERVIEW OF ALICE RESULTS ON ULTRA-PERIPHERAL COLLISIONS

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Pb nuclei, accelerated at LHC, are sources of strong electromagnetic fields that can be used to measure photon-induced interactions in a new kinematic regime. These interactions can be studied in ultra-peripheral p-Pb and Pb-Pb collisions where impact parameters are larger than the sum of nuclear radii and hadronic interactions are strongly suppressed. Heavy quarkonium photoproduction is of particular interest since it is sensitive to gluon distributions in target hadrons. Overview of ALICE results on vector meson photoproduction in ultra-peripheral Pb-Pb collisions and p-Pb collisions will be presented. Implications for the study of gluon density distributions and nuclear gluon shadowing will be discussed.

STATUS OF NEUTRINO OSCILLATIONS

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The review of the present status and futures perspectives of study neutrino oscillations in accelerator and reactor experiments will be presented. The results obtained in current long baseline accelerator experiments T2K and NOvA are discussed. An emphasis is put on a search for CP violation in neutrino oscillations. The brief overview and status of the next generation accelerator based experiments T2HK (Japan) with 260 kt Hyper-Kamiokande far neutrino detector and DUNE (USA) with 40 kt LAr TPCs will be given. Finally, the recent progress and results obtained in searches for light sterile neutrinos in accelerator and reactor experiments will be discussed.

THE COMPRESSED BARYONIC MATTER EXPERIMENT AT FAIR

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This talk will give an overview of the Compressed Baryonic Matter (CBM) experiment. The CBM is currently under construction at FAIR in Darmstadt. High-intensity heavy-ion beams delivered by the SIS100 accelerator (FAIR Phase 1) will be used to explore the QCD phase diagram in the region of neutron-star core baryon-densities. Interaction rates of up to 10 MHz on a fixed target will enable measurements at an unprecedented level of precision and thereby allow access to rare probes like, e.g., multi-strange hyperons and hyper-nuclei. In-medium mass distributions of vector mesons can be measured via lepton pairs, and excitation functions of various observables will serve as sensitive probes for phase transitions.

THE NUCLEAR EMC EFFECT IN THE RESONANCE AND DIS TRANSITION REGION

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We discuss a model of the proton and the neutron structure functions in the resonance and the DIS transition region. The model utilizes the results of empirical fit of the proton structure function in the resonance region [1] as well as the results of the global proton PDF analysis to the NNLO QCD approximation [2]. We discuss application of this model to compute the structure functions of a few-body nuclei and compare our results with recent mesurements of the nuclear EMC effect in ^{2}H (deuteron) [3], ^{3}He and ^{4}He [4] nuclei. We also discuss applications for the extraction of the F_2^n/F_2^p ratio from the measurements with ^{2}H [5] and ^{3}He nuclei in the region of large Bjorken x.

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MC SIMULATION RESULTS FOR PROJECTIVE GEOMETRY VERSION OF MPD EMC AT NICA COLLIDER

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The report gives a description of Monte Carlo simulation software developed for projective geometry version of electromagnetic calorimeter of MPD-detector. At the first stage .root file is created which transfer all EMC geometry information to GEANT4. EMC consists of 4308 modules of shashlik-type. Each module is a truncated pyramid with the base of 4x4 cm^2 and 43 cm height filled with 221 layers of 1.5 mm thick scintillator plates interleaved by 0.3 mm thick Pb-plates. Side surfaces of the modules are machined so that they compactly fill cylindrical layer with internal radius of 1.72 m and 6.28 m long (336 modules on circumference and 128 modules along cylinder Z-axis). An axis of each module points to the interaction point at the cylinder center. 64 different types of the modules are used. Total weight of the EMC is nearly 60 tons. Geometry file gives a description of 16M "volumes". At the second stage the software analyses GEANT4 output file, produces hits – responses of the modules (deposited energy, time and module number) and creates clusters. Test results of the software and EMC MC performance are also presented. They include precision test of module positions, EMC efficiency to different particles, energy and angle resolution, resolution in neutral pion mass, registration of high multiplicity events and others.

FEASIBILITY STUDY OF FRAGMENTATION METHOD OF LUMINOSITY MEASUREMENT FOR NICA COLLIDER

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Zero angle production of nuclear fragments in heavy ion collisions has an attractive feature for luminosity measurement at heavy ion colliders and is used at RHIC and LHC. Fragmentation cross section is large and has a narrow momentum distribution for each type of the fragment. For luminosity measurements, only the fragments with rigidity different from that of the beam nucleus are of interest due to possibility to use bending magnets of collider to separate these fragments from the beam. The best fragments are neutrons and protons. The later has rigidity 2 times smaller than a carbon projectile and 2.49 times for gold. In this report we consider a possibility to use o NICA collider beam focusing system for luminosity measurements. This system consists of two identical parts placed at opposite sides of interaction point at a distance 5-15 meters from it. They include triplet of quadrupole lenses and three bending magnets. One of these magnets, which is common for both beams can be used for deflection of protons from beam pipe and deflection of beam from straight neutron path. The report presents simulation of luminosity monitor with detector plane in 2 m from the end of the bending magnet. LAQGSM was used for simulation of nuclear fragmentation and precise calculation of beam optic has been performed. Main collimator of 10 cm in diameter was placed at the entrance of the bending magnet at 11.905 m from interaction point. The bending magnet deflects the protons by 7 cm from beam pipe at detector plane. In spite of triplet defocusing properties, proton counting rate is nearly 500 per second for Au+Au collisions at sqrt(s) = 11 GeV/nucleon and luminosity of 10^{27} $cm^{-2}c^{-1}$. It looks sufficient for luminosity measurement. Results for this counting rate for lower energies and for other colliding nuclei are also presented.

GEM / CSC TRACKING SYSTEM OF THE BM@N EXPERIMENT AT THE NUCLOTRON

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BM@N (Baryonic Matter at the Nuclotron) is the fixed target experiment aimed to study nuclear matter in the relativistic heavy ion collisions at the Nuclotron accelerator in JINR. The BM@N tracking system is based on Gas Electron Multipliers (GEM) detectors, mounted inside the BM@N analyzing magnet. Cathode Strip Chamber (CSC) is installed outside the magnet. CSC is used for improvement of particles momentum identification. The structure of the GEM detectors and CSC and the results of study of their characteristics are presented. The GEM detectors and CSC are integrated into the BM@N experimental setup and data acquisition system. The results of first tests of the GEM tracking system and CSC in last runs are shortly reviewed.

ANALYSIS OF THE $pp \to \{pp\}_s\pi^0$ REACTION AT THE ENERGY RANGE 0.8–2.8 GeV

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We present the results on measurements of the differential cross section for the reaction $pp \to \{pp\}_s\pi^0$ where $\{pp\}_s$ is a $^1S_0$ proton pair (diproton) with the excitation energy $E_{pp} < 3$ MeV. The data were obtained with the ANKE magnetic spectrometer at the COSY-Jülich synchrotron(Germany). The measurements have been performed at a number of proton beam energies in the 0.8–2.8 GeV range. The angular range of the $\{pp\}_s$ diproton in the reaction center-of-mass system was $0^\circ < \theta_{pp} \lesssim 18^\circ$.

The results in the form of the differential cross section are analyzed together with those obtained earlier by the ANKE collaboration [1, 2]. The energy spectrum of the zero-degree cross section exhibits a pronounced peak at the 1.5–2.2 GeV beam energies. Besides, within the peak region the obtained differential cross sections have a maximum at zero angle and drop with the increase of diproton angle, unlike those at the energies outside this energy interval. This could be an indication for a change of reaction dynamics responsible for the observed peak in the forward cross section. The mass and width of the peak are obtained by fitting within the framework of a simple "isobar" model with $\Delta(1620)$ excitation in the intermediate state.

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DETERMINATION OF CENTRALITY IN NUCLEUS – NUCLEUS COLLISIONS ON THE MPD/NICA INSTALLATION

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Measurement of the number of spectators in nucleus-nucleus collisions allows to determine the number of nucleons participating in the interaction, i.e. get information about the centrality of the collision. However, at energies of the NICA collider the forward hadronic calorimeter does not have sufficient energy resolution for the separation of the amplitudes, the corresponding to different number of spectators. Uncertainty in the number of spectators leads to a large mistake in determining of centrality. For central events inaccuracy in the determination of the collision parameter is about 40%, for peripheral ones is not better than 30% at a beam energy of 2.5 AgeV. Scintillation multiplicity detector will allow obtaining more accurate data. A method for determining centrality is proposed taking into account the real the geometry of the MPD installation.

INVESTIGATION OF ELECTRIC FIELD IN SIPM ACTIVE VOLUME BY VOLT-FARAD CHARACTERISTICS ANALYSIS

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The aim of this study is to understand a changing of SiPM structure after irradiation. We compared profile of electric field in SiPM (KETEK) active region for ten not-irradiated and irradiated detectors. Standard method of measurement of C-V characteristics was applied using two configurations (serial and parallel circuit) to exclude an influence of the serial resistance. Dependencies of capacitance on frequency was studied in range from 10 to 1000 KHz. For non irradiated detectors we detected in CV characteristics local instability basically connected with accumulation of charge on boundary optical isolator-silicon. Also hysteresis of C-V characteristics was detected. For irradiated detectors also local instability was visible, but hysteresis of C-V characteristics was not detected. The results demonstrate that applied method can be used for relative analysis how SiPM active region properties changed after irradiation.

INTERACTION OF QUANTUM SYSTEMS WITH ENVINRONMENT IN QCD

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To study the properties of colour particle *states behaviour in the QCD vacuum* we calculate the density matrix of the system colour particle - stochasticQCD vacuum, considered as environment, and averaged over degrees of freedom of the environment.As a result the density matrix of colour particle is depended on the Wilson loop which depends on spanned area RT.

In the stochastic vacuum Wilson loop decays exponentially with RT at large distances and we obtain evident form of density matrix of colour particle moving in the stochastic QCD vacuum.

Learning density matrix we obtain characteristics of colour particle: purity (closeness of a quantum state to a pure one), von Neiman entropy, information, fidelity (measure of quantum motion stability). The quantities are calculated for different initial colour states: superposition, pure, mixed, separable, non-separable (entangled), multiparticle.

In the case of of stochastic (not coherent) QCD vacuum (only correlators of the second order are important) in confinement region (Wilson loop decays exponentially) we have decoherence of pure colour states into a mixed white states, while purity decays exponentially (decay rate = string tension).For multiparticles (pure separable, mixed separable and nonseparable (entangled) states) when RT -> ∞ we obtain diagonalization of density matrix, decreasing of purity and increasing of vonNeumann entropy.

ENERGY DEPENDENCE OF THE VECTOR A_y AND TENSOR A_{yy} AND A_{xx} ANALYZING POWERS IN DEUTERON- PROTON ELASTIC SCATTERING AT LARGE SCATTERING ANGLES

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The results on the angular dependencies of the vector A_y and tensor A_{yy} and A_{xx} analyzing powers in deuteron-proton elastic scattering at large scattering angles are presented. These data were obtained at internal target at JINR Nuclotron in the energy range 400-1800 MeV using polarized deuteron beam from new polarized ion source [1].

New data on the deuteron analyzing powers in in the wide energy range demonstrate strong sensitivity to the short-range spin structure of the isoscalar nucleon-nucleon correlations observed earlier [2].

The perspectives of further studies of the short-range correlations using carbon, polarized deuteron and proton beams are discussed.

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CHIRAL STUDY OF THE FOUR-QUARK STATE $f_0(500)$ IN PION-PION AND PION-NUCLEON SCATTERING

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We investigate the two-flavor version of the extended linear sigma model (eLSM), which contains, besides the standard scalar and pseudoscalar quark-antiquark degrees of freedom, also vector and axial-vector mesons, as well as the nucleon and its chiral partner. We extend this model by an additional light scalar meson, the predominantly four-quark state $f_0(500)$: At the same time, we also do not freeze the scalar glueball (predominantly corresponding to $f_0(1710)$). We investigate interaction terms of these states with the other particles, some of which preserve and some of which explicitly break the $U_{\rm A}(1)$ symmetry. We test our model by performing a global fit to masses and decay widths of the scalar resonances and pion-pion scattering lengths. We also discuss the influence of the scalar four-quark state and the glueball on the baryon sector by evaluating pion-nucleon scattering parameters. We find that the inclusion of $f_0(500)$ as predominantly a four-quark state is necessary for a correct description of pion-pion and pion-nucleon scattering length.

E-BY-E FLUCTUATIONS OF INITIAL CONDITIONS IN INTERACTIONS OF LIGHT, INTERMEDIATE AND HEAVY NUCLEI AT ENERGIES 4 – 200 GEV AT NUCLEON

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Better understanding the fluctuating structure in the initial conditions of nuclear interactions is one of the most important heavy ion physics problems. In the present report these problems are studied in the centrality selected interactions of light – (C, O, Ne), intermediate - (Si, S) and heavy – (Au, Pb) ions with light – (C/N/O) and heavy – (Ag/Br) nuclei on the data of JINR-AGS-SPS target emulsion experiments. The new centrality selection approach without any nuclear geometry models was proposed and realized for this goal. The analyses have performed in variables of multiplicity and pseudorapidity. The actual problem of fluctuations in transverse plane does not consider.

Independent and accurate measurement in each event correlations between charged multiplicity and sum of all fast charged fragment-spectators: proton-spectators, alpha-particle-spectators and heavy mass fragment-spectators open the way for effective estimation of the E-by-E fluctuations of multiplicity. The study in each event the third and fourth statistical moments of pseudorapidity distribution gives us a clear picture of E-by-E fluctuations for the longitudinal event shape.

The evolution of experimental fluctuation patterns has estimated in two directions: “on vertically” and “on horizontally”. In the “vertical analysis” E-by-E fluctuations in interactions of each group of nuclei, - light-light - (C, O, Ne) + (C/N/O), intermediate-light - (Si, S) + (C/N/O) and heavy-heavy - (Au, Pb) + (Ag/Br), - have been compared with each other at a given level of centrality: at “most central”, at “mid-central” and at“ peripheral”. In the “horizontal analysis” E-by-E fluctuations in these groups of interactions have been compared with each other at a different level of centrality: from “most central”, via “mid-central” and to “peripheral”.

This approach complements previous data of our research group [1, 2], which showed that there is a clear trend to the E-by-E fluctuation increasing with system size decreasing for central interactions of light-light - (C, O, Ne) + (C/N/O), intermediate-light - (Si, S) + (C/N/O) and heavy-heavy - (Au, Pb) + (Ag/Br) nuclei. The strong enhancement E-by-E fluctuations in multiplicity and pseudorapidity for the most central collisions of (C, O, Ne) + (C/N/O) was interpreted as the sign of intrinsic alpha-clustering in light nuclei.

In order to make the reliable inference on the system size and structure dependence for multihadron production processes, the new physical approaches and experiments with high resolution and statistics are needed. New project “NICA” opens the excellent possibilities for this goal. Actual system size problems can be studied on the first stage of NICA project – target experiment “Baryonic Matter at Nuclotron” (“BM@N”). It is very interesting to perform comparative analysis of multiparticle processes in p + p, C + C and Au + Au collisions at new JINR energies at MPD.

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RECENT RESULTS OF THE HADRONIC CROSS SECTION MEASUREMENTS WITH THE CMD-3 DETECTOR

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In 2017-2018 the CMD-3 detector continued collecting data at the electron-positron collider VEPP-2000. After upgrading the positron injection facility, an average luminosity increased by a factor of three. In 2017 the scan was performed in the center-of-mass energy range from 1 to 2 GeV while in 2018 we scanned the energy region below 1 GeV to measure the pion form factor and omega meson parameters more accurately. The beam energy was monitored continuously during data taking with precision about 100 keV using Compton backscattering techniques. The analysis of the collected data confirmed our previous result - sharp behavior of the six pion cross section near the threshold for nucleon-antinucleon pair production. In addition, we observed for the first time a similar anomaly in the cross section for the process $e^+e^- \to K^+K^-\pi^+\pi^-$ in the same energy region. Preliminary results for some other hadronic channels are also presented.

EMPLOYMENT OF MICROSCOPIC MODEL OF OPTICAL POTENTIAL FOR TESTING THE $^{12,14}Be + p$ ELASTIC SCATTERING AT 700 MEV

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The experimental data [1] on the $^{12,14}Be+p$ elastic scattering differential cross sections at 700 Mev are compared with those obtained by solving the relativistic wave equation with the microscopic optical potential [2] calculated by using densities of the $^{12,14}Be$ nuclei in the form of the phenomenological symmetrized Fermi function with two fitted parameters and also in forms obtained with the help of the microscopic models in the so-called Generator coordinate method (GCM) [3] and of the Variational method of calculations (VMC) [4]. In the case of ^{12}Be the both microscopic models turn out in small disagreement with the data at "large" angles $\theta \geq 9^{\circ}$, while for the ^{14}Be one sees some inconsistence also at smaller angles.

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ON A SEARCH FOR NEW LIGHT CHARGED PARTICLES IN PHOTOPRODUCTION

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Motivated by recent V.A. Nikitin's reports on observation of 9-MeV/c^2 charged particles with a 2 meter JINR propane bubble chamber we perform an experiment at the LPI electron synchrotron "Pakhra" with the aim to detect such particles in the Bethe–Heitler process. Theoretical limits for masses of new light charged particles of spin 0, 1/2 and 1 arising from precise data on the muon anomalous magnetic moment are recalculated and updated. A geometry of the photoproduction experiment is proposed that optimizes sigma-to-noise ratio. Preliminary results of the experiment are exposed.

SELF-CONSISTENT ANALYSIS OF HADRON PRODUCTION IN pp, pA AND AA COLLISIONS AT MID-RAPIDITY

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The self-consistent approach based on similarity of inclusive spectra of hadrons produced in pp and AA collisions is reviewed. This approach allows us to describe rather well the ratio of proton to anti-proton yields in AA collisions as a function of the initial energy at a wide range from a few GeV to a few TeV. We suggest its modification due to the quark-gluon dynamics to describe the inclusive spectra of hadrons produced in pp collisions as a function of the transverse momentum p_t at mid-rapidity. The extension of this approach to analyze the pion p_t-spectra produced in pA and AA collisions at high and middle energies and mid-rapidity is given. The satisfactory description of experimental data on these spectra within the offered approach is shown.

ON THE PAIR CORRELATIONS OF NEUTRAL K, D, B AND B_S MESONS WITH CLOSE MOMENTA PRODUCED IN INCLUSIVE MULTIPARTICLE PROCESSES

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The phenomenological structure of inclusive cross-sections of the production of two neutral K mesons in hadron–hadron, hadron–nucleus and nucleus–nucleus collisions is theoretically investigated taking into account the strangeness conservation in strong and electromagnetic interactions. Relations describing the dependence of the correlations of two short-lived and two long-lived neutral kaons $K^0_S K^0_S$, $K^0_L K^0_L$ and the correlations of "mixed" pairs $K^0_S K^0_L$ at small relative momenta upon the space-time parameters of the generation region of K^0 and $\bar{K}^0$ mesons have been obtained. These relations involve the contributions of Bose-statistics and S-wave strong final-state interaction of two K^0 ($\bar{K}^0$) mesons as well as of the K^0 and $\bar{K}^0$ mesons, and also the additional contribution of transitions $K^+K^- \to K^0\bar{K}^0$, and they depend upon the relative fractions of generated pairs K^0K^0, $\bar{K}^0\bar{K}^0$ and $K^0\bar{K}^0$. It is shown that under the strangeness conservation the correlation functions of the pairs $K^0_S K^0_S$ and $K^0_L K^0_L$, produced in the same inclusive process, coincide, and the difference between the correlation functions of the pairs $K^0_S K^0_S$ and $K^0_S K^0_L$ is conditioned exclusively by the production of the pairs of non-identical neutral kaons $K^0\bar{K}^0$.

For comparison, analogous correlations for the pairs of neutral heavy mesons D^0, B^0 and B^0_s, generated in multiple inclusive processes with charm (beauty) conservation, are also theoretically analyzed – neglecting, just as for the case of K^0 mesons, the weak effects of CP violation. These correlations have the quite similar character and they are described by quite similar expressions: in particular, just as for K^0 mesons, the correlation functions for the pairs of states with the same CP parity ($R_{SS} = R_{LL}$) and with different CP parity (R_{SL}) do not coincide, and the difference between them is conditioned exclusively by the production of pairs $D^0\bar{D}^0$, $B^0\bar{B}^0$ and $B^0_s\bar{B}^0_s$. However, contrary to the case of K^0 mesons, here the distinction of CP-even and CP-odd states (and, hence, the experimental study of respective pair correlations) encounters difficulties – due to the insignificant differences of their lifetimes and the relatively small probability of purely CP-even and CP-odd decay channels. Nevertheless, one may expect that this will become possible at future colliders.

ON THE ρ^0-MESON PRODUCTION IN THE INCLUSIVE PROTON-PROTON COLLISION

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It's shown [1] that the extended parton model with an isotropic distribution of the ρ^0 meson reproduces realistically the experimental cross sections of the inclusive proton-proton scattering $p_A + p_B \to \rho^0 X$. This is consistent with the experimental results [2], according which the angular distributions of this reaction at $P_{lab} = 12$ *and* $24 GeV/c$ are roughly isotropic.

Present formulation of the reaction $p_A + p_B \to \rho^0 + X$ based on extension of the original parton model for the Drell-Yan reaction $p_A + p_B \to \gamma * + X$ within generalized vector meson dominance (GVMD) model which requires continuation of the parton distribution functions (PDF) in the region of the small x and $Q^2 < 1 GeV^2$ and contains exactly the quark-antiquark-ρ meson vertex which is constructed via the vector g_V and tensor g_T coupling constants of the $\rho - NN$ vertex. We have used three different PDF $f_{n/A}(x)$ [3, 4, 5], where for $|x| << 1$ and $Q^2 < 1 GeV^2$ PDF are constructed exactly [3, 4] using the corresponding experimental data.

We take PDF $\mathsf{f}_{n/A}(x, \mathbf{q}_T)$ as

$$\mathsf{f}_{n/A}(x, \mathbf{q}_T) = f_{n/A}(x) \frac{e^{-\mathbf{q}_T^2/(2b^2)}}{2b^2}; \qquad \mathsf{f}_{\overline{n}/B}(x, \mathbf{q}_T) = f_{\overline{n}/B)}(x) \frac{e^{-\mathbf{q}_T^2/(2b^2)}}{2b^2}, \tag{1}$$

where $\mathbf{q_T}$ denote the transverse momentum of the quark, $P = |\mathbf{P}|$ is the momentum of the beam proton in c.m. system; $x_{1.2} = \frac{k_o \pm k_Z}{2P}$, and $k^o = \sqrt{m_V^2 + \mathbf{k_T}^2 + k_Z^2}$ is the energy of final ρ-meson with the mass m_V and the longitudinal momentum k_z..

We have obtained, that the cross section for the isotropic distributions contains only two adjustable parameters: $2b^2$ from the standard PDF (1) and the related constants $(g_V - g_T)^2$. The considered cross section depends on the quark masses through $(g_V - g_T)^2$. This allows one to get the several set of the different quark masses which yield the same cross section with the same $(g_V - g_T)^2$. In particular, we have demonstrated that one can obtain the same isotropic distributions within the constituent and current quark models. The detailed theoretical and experimental investigation of the anisotropic contributions in the considered cross sections will allow one to estimate the mechanisms of removing this degeneracy.

As an example of the present formulation we shall examine the total cross section of the reaction $p_A + p_B \to \rho^0 X$. Total cross section $\sigma_{p_A + p_B \to \rho^0 X}$ in Fig. 1 significantly depend on the choice of PDF and parameters $2b^2$ in (1) and $(g_T - g_V)^2$. However, these cross-sections have important features:

1) They increase dramatically in the energy region up to $\sqrt{s} \sim 20 GeV$. In particular, $\sigma_{p_A + p_B - \rho^0 X}(P_{beam} = 24 Gev/c) / \sigma_{p_A + p_B - \rho^0 X}(P_{beam} = 12 Gev/c) \simeq 2$.

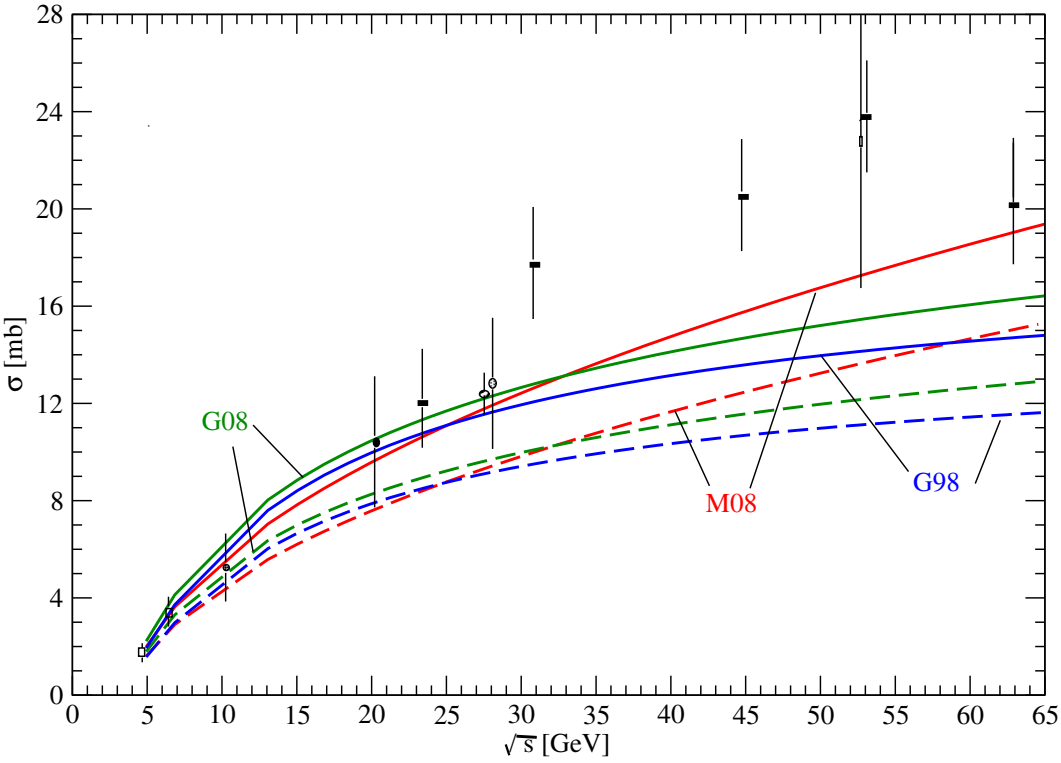

Figure 1: *Total cross section* $\sigma_{p_A+p_B-\rho^0 X}$ *as a function of* $\sqrt{s}$. *[M08], [G98] and [G08] indicate curves with the PDF from [5, 3] and [4] correspondingly. Solid and dashed lines correspond to* $0.4082 GeV/c$ *and* $b = 0.3727$ *in PDF (1). Articles with experimental data are quoted in [1].*

2) In the energy region $\sqrt{s} > 20GeV$ these cross sections are growing much slower than before $\sqrt{s} < 20GeV$. The isotropic cross section $\sigma_{p_A+p_B\to\rho^0 X}$ strongly depends on the choice of the parameters $2b^2$ in PDF (1) and the corresponding parameter $(g_V - g_T)^2$. Sensitivity on the correlated parameters $2b^2$ and $(g_V - g_T)^2$ of this cross section increases in the region $20GeV < \sqrt{s} < 65GeV$.

This theoretical model [1] presents the first qualitative description of the inclusive reaction $p_A + p_B - \rho^0 X$

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THE FAST INTERACTION TRIGGER DETECTOR FOR THE UPGRADE OF THE ALICE EXPERIMENT AT CERN: DESIGN AND PERFORMANCE

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ALICE (A Large Ion Collider Experiment) experiment [1] at CERN LHC is designed to study the properties of the Quark-Gluon Plasma (QGP) in heavy-ion collisions. In 2019-2020 the upgrade of CERN LHC will increase the luminosity and the collision rate beyond the design parameters of the current ALICE setup. To be able to benefit from the improved performance of the LHC, ALICE will upgrade several of its key detector systems including the Fast Interaction Trigger (FIT) [2]. FIT is designed to provide the functionality of the old forward detectors while retaining or even improving their performance. It will provide Minimum Bias trigger with efficiency higher than 90% for pp collisions, measure luminosity for pp and Pb-Pb, sustain interaction rates up to 1MHz and 50kHz, respectively. FIT will determine the collision time with a resolution better than 50ps, and will be used to measure the event multiplicity, the centrality and the reaction plane. The detector consists of 2 arrays of Cherenkov radiators with MCP-PMT sensors, placed on both sides of the interaction point and of a single large-diameter scintillator ring. This presentation will discuss the main design concepts, detector construction, beam test results, MC simulations, and the results of detector performance studies.

Acknowledgements. This work was performed as part of the RF Ministry of Education and Science’s program for Russian teams to participate in the project for modifying the ALICE experiment at the Large Hadron Collider.

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PHASE TRANSITIONS IN THE EXTENDED PARTICLE SYSTEMS, HAGEDORN TEMPERATURE AND CRITICAL DENSITY AND THE FRACTAL DIMENSION OF SPACE, AS A CONFINEMENT PHASE TRANSITION ORDER PARAMETER

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Concise introduction in renormdynamics and fractal calculus; boson, fermion, and super oscillators and (statistical) mechanism of cosmological constant; finite approximation of the zeta-function and fermion factorization of the bosonic statistical sum considered.

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FRAGMENTATION PEAK SPLITTING OF THE LIGHT IONS IN ^{56}Fe + ^{9}Be COLLISIONS AT 0.23 GeV/NUCLEON

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The FRAGM experiment at the ITEP-TWA heavy ion facility has a specific possibility to measure the momentum distributions of nuclear fragments [1]. In this paper we present the results of ^{56}Fe fragmentation into light ions on Be target at 0.23 GeV/nucleon and angle of 3.5°. The momentum spectra of projectile like fragments were measured with high resolution beamline spectrometer. Fragments were selected by correlated time of flight and dE/dx measurements with scintillation detectors. In contrast to the carbon fragmentation [2], where the momentum spectra have Gaussian-like shapes, in the fragmentation of iron ions into the light fragments the shapes have a double-humped structure.

This splitting is most pronounced in proton spectra, decreases with increasing fragment mass and disappears for lithium isotopes and heavier fragments. The possibility of describing this effect in asymmetric fission, coalescence model and multi-fragmentation is discussed. A comparison is made with the results of the FRS measurements in GSI [3], where a similar effect was observed in the fragmentation of iron and xenon ions into lithium and boron isotopes at 1 GeV / nucleon . The obtained experimental data is in a reasonable agreement with the predictions of several transport codes such as BC, INCL and LAQGSM.

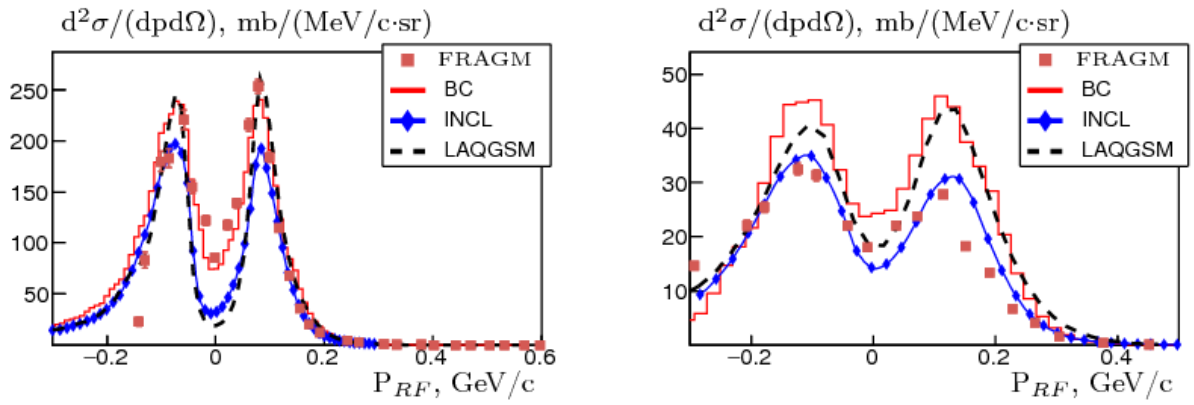

Fig. 1. Momentum spectra of fragment in the projectile rest frame for protons (left) and deuteron (right) presenting the experimental data (FRAGM) and different transport codes.

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ENERGY SPECTRA OF MUONIC ATOMS IN QUANTUM ELECTRODYNAMICS

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The hyperfine splitting (HFS) of 2S-state in muonic hydrogen was measured recently by the CREMA collaboration in [1]:

$$\Delta E^{hfs}_{exp}(2S) = 22.8089(51)\ meV. \tag{2}$$

At present, several experimental groups plan to measure the HFS of the ground state in muonic hydrogen with a record accuracy of 1 ppm. The CREMA collaboration has obtained in recent years significantly new experimental results that helped to re-examine the problem of muon bound states, posed new questions to the theory that require additional investigation. One possible future activity of the CREMA collaboration may be connected with other muonic ions containing light nuclei of lithium, beryllium and boron. For these muonic ions, the description of the electromagnetic interaction of the few-nucleon systems is particularly important, and, consequently, the role of the effects of nuclear physics can be studied with greater accuracy.

In our previous work, we calculated the Lamb shift in the muonic ions of lithium, beryllium, and boron [2]. In this work we carry out a calculation of S-states hyperfine splittings in a number of muonic ions. Our precise calculation of the HFS includes taking into account the various corrections of the fifth and sixth orders in α, which were previously taken into account also in the study of the hyperfine structure of the spectrum of muonic hydrogen and helium. One significant difference between these calculations and the previous ones is due to the fact that in this work we investigate the nuclei of spin 1, 3/2, 3. Corrections to the structure of the nucleus, which are determined by two-photon exchange amplitudes, as follows from our results, play a very important role in achieving high accuracy of calculation. They are defined in our approach by the electromagnetic form factors of the nuclei, which in this case must be taken from experimental data. Several basic corrections calculated in [3] are in agreement with our results.

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HADRONIC CONTRIBUTION OF LIGHT BY LIGHT SCATTERING IN THE ENERGY SPECTRUM OF MUONIC HYDROGEN

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Among the various electromagnetic interactions, the processes of two-photon meson production take a special place. First, they have been studied experimentally for quite a long time, for which a rich material has been accumulated [1, 2]. Secondly, with the development of the quark model and nonperturbative methods of quantum chromodynamics, such reactions, as well as the reverse decay processes of mesons into two photons, were constantly in the field of intensive theoretical studies.

A new round of interest in $\gamma + \gamma \to$ *meson* processes is connected with their possible role as a new source of interactions between leptons and nucleons. Since in atomic physics there are precise experiments to measure fine and hyperfine structure, any new contributions to the particle interaction operator are important and can be studied experimentally. The first estimate of the contribution of effective meson exchange in muonic hydrogen, which have already appeared, show that this contribution is significant [3, 4].

In our previous papers [3, 4] we have investigated the role of effective exchanges of axial vector and pseudoscalar mesons for the position of the energy levels in muonic hydrogen. In this study we extend our analysis to the case of scalar mesons. There are several scalar mesons with the mass near 1 GeV, which can contribute to the effective muon-proton interaction: $\sigma(550)$, $f_0(980), a_0(980)$, $f_0(1370)$. On the basis of quasipotential method in quantum electrodynamics we construct the muon-proton interaction amplitudes due to scalar meson exchange. Analytical expressions for corresponding energy shifts in the case of 2S- and 2P-states are obtained. Using quark model we calculate parameters of two-photon - scalar meson transition form factor and obtain numerical estimate of the contribution to the Lamb shift (2P-2S) in muonic hydrogen.

The work is supported by RSF 18-12-00128 and RFBR 18-32-00023.

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PREDICTION FOR THE ATOM, NUCLEAR MASS AND MASS EXCESS OF 119 AND 120 ARTIFICIAL ELEMENTS USING THE IMPROVED NUMERICAL GENERALIZATION OF BETHE- WEIZSACKER MASS FORMULA BY TAKING INTERACTION OF THE ELECTRON SHELL AND NUCLEUS

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In this paper is presented explicit improved numerical generalization of Bethe-Weizsacker (BW) mass formula which describes the values of measured 2654 nuclear mass in AME2012 nuclear database with residual less than 1.6 MeV, starting from 2H1 to 294Og118.

In the obtained generalization of the BW formula the influence of magic numbers and boundaries of their influence between them is defined for ten protons (2, 8, 14, 20, 28, 50, 82, 98, 108, 124), eleven neutrons (2, 8, 14, 20, 28, 50, 82, 124, 152, 184, 202)- from fit, and electrons (2, 10, 18, 36, 54, 86, 118 140) magic numbers- from Mendeleev table of elements.

In the last years appeared new experimental data which demonstrate the dramatically change of decay rate due to ionization of atom, because of the resonant interaction between electron shells and nuclei.

For example, the strong dependence of the nuclear decay rate appeared for the 229Th90, 226Rn88, 152Eu63 154Eu63 isotopes and 178mHf72, 99mTc43 isomers.

RECENT RESULTS FROM STRONG INTERACTION PROGRAM OF NA61/SHINE EXPERIMENT AT CERN SPS

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Exploration of predicted features of the phase diagram of strongly interacting matter particularly the deconfinement phase transition from hadrons to a system of quasi-free quarks and gluons (QGP) and quest for the critical point is the primary goal of a number of contemporary experiments, developing projects and numerous theoretical investigations.

The NA61/SHINE experiment at CERN SPS pursuing this challenging program performing a two-dimensional scan a broad region of the QCD phase diagram by varying the momentum (13A-158A GeV/c) and the size of colliding systems (p+p, p+Pb, Be+Be, Ar+Sc, Xe+La and Pb+Pb).

Recent NA61/SHINE results on particle spectra and event-by-event fluctuations in p+p, Be+Be and Ar+Sc collisions will be discussed. Emphasis is put on the measurements of particle ratios, namely of pion and strangeness production, and multiplicity fluctuations versus the energy and the system size.

It will be shown that the hadron production properties in heavy ion collisions which change rapidly in the low SPS energy domain and interpreted as the beginning of creation of quark-gluon plasma - onset of deconfinement could be also the case in inelastic p+p interactions and probably in Be+Be collisions.

The observed rapid change of hadron properties that start when moving from Be+Be to Ar+Sc will be explained that can be interpreted as the beginning of formation a large clusters of strongly interacting matter - onset of fireball.

Recently the experimental program was extended by measurements of production properties of open charm mesons. For this purpose the NA61/SHINE spectrometer was supplemented with a Vertex Detector, which allowed identification of D0 mesons in the first test measurements performed for Pb+Pb collisions at 150A GeV/c.

As an extension of physics program NA61/SHINE plans to measure precisely an open charm and multi-strange baryon production. The physics program for future measurements beyond 2020 will be briefly presented as well as the planned upgrade of the NA61/SHINE facility.

STUDY OF THE DEUTERON ANALYZING POWERS IN DP-ELASTIC SCATTERING AT THE ENERGY OF 800 MeV

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The preliminary results on the angular distributions of the vector A_y and tensor A_{yy}, A_{xx} analyzing powers in dp- elastic scattering at the energy of 800 MeV are presented. The measurements have been performed at Internal Target Station at Nuclotron using polarized deuteron beam from new source of polarized ions. The experimental data are compared with the preliminary calculations obtained within framework of relativistic multiple scattering approach.

ETA-NUCLEI IN THE SCAN EXPERIMENT

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Eta-mesic nucleus or the quasibound nuclear state of an η-meson in a nucleus is caused by strong-interaction force alone. The project SCAN2 is aimed at searching and studying eta-meson nuclei production. The experiment is based on two-arms spectrometer using internal target at the Nuclotron. The setup was designed to study products from eta-meson nucleus decay in the reaction $d + {}^{12}\mathrm{C} \to (A)_\eta + X \to \pi + p + (A-2)$ at deuteron energies from 0.5 to 2.5 $GeV/nucl$. The energy spectrum of secondary protons has been measured. The dependence of the yields of protons and pions on the beam energy has been obtained. This dependence can show us the minimum energy for S_{11} resonance formation. The first prototype of the neutron detector has been tested, which will be used in a new modified experimental setup SCAN3 for recording of nucleons and pions from η-nucleus decays in the πn and pn channels. Time-of-flight method to obtain neutron spectrometry was used. Time resolution and efficiency of neutron detector has been obtained.

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THE VERY FORWARD HADRON CALORIMETER PSD FOR THE FUTURE CBM@FAIR EXPERIMENT

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The Projectile Spectator Detector (PSD) of the CBM experiment at the future FAIR facility is designed to measure the energy distribution of the forward going projectile nucleons and nuclei fragments (spectators) produced close to the beam rapidity. The PSD is a compensating calorimeter which has a modular transverse structure consisting of 44 modules with a beam hole in the center of the calorimeter. Each module has 5.6 hadron interaction lengths and transverse size of 200x200 mm^2. The module consists of 60 lead/scintillator sandwiches with the sampling ratio of 4:1. Light from each of 6 consecutive scintillator plates in module is collected by WLS fibers and is read out by one photodetector, 3x3 mm^2 Hamamatsu MPPC placed at the end of the module. Thus, the module has the readout from 10 longitudinal sections that allows to measure the longitudinal hadron shower profile.
Calorimeter will provide the information on the centrality and reaction plane orientation of the heavy-ion collisions at the SIS-100 beam energy range of 2 - 10 AGeV with beam interaction rates up to 1 MHz. The detector performance for the centrality and reaction plane determination will be presented based on Monte-Carlo simulations of gold-gold collisions with help of four different heavy-ion event generators.
The PSD energy resolution and the linearity of the response have been measured at CERN Proton Synchrotron (PS) T9 and T10 beam lines for PSD supermodule consisting of 9 modules assembled in 3x3 array.
Predictions of the calorimeter radiation conditions at the CBM and response measurement of one PSD module with 10 neutron irradiated MPPCs used for the light read out will be discussed.

PROSPECTS FOR THE STUDY OF EVENT-BY-EVENT FLUCTUATIONS AT MPD/NICA PROJECT

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One of the main physic goal of the Multi Purpose Detector (MPD) is to investigate hot and dense baryonic matter in heavy ion collisions at NICA energies for the searching of the possible critical end point (CEP). Since the location of CEP is not really known the entire accessible region of the QCD phase diagram needs to be explored by scanning the full range of available beam energies. In case of presence CEP can be observed by abnormal fluctuations of various quantities such as net-proton multiplicity.

This task requires excellent particle identification (PID) capability over as large as possible phase space volume. The identification of charged hadrons is achieved at the momenta of 0.1 – 3 GeV/c. In my talk I will present results of hadron identification and preliminary possibility estimation of the study of event-by-event fluctuations at MPD.

MULTI PARTICLE PRODUCTION IN PROTON-NUCLEUS COLLISIONS AT HIGH ENERGY

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Using the formalism of the light-cone wave function in perturbative QCD together with the hybrid factorization, we compute the cross-section for three particle production at forward rapidities in proton-nucleus collisions. In this picture, the three produced partons a quark accompanied by a gluon pair, or two quarks plus one antiquark are all generated via one or two successive splittings of a quark from the incoming proton, that was originally collinear with the latter. The three partons are put on-shell by their scattering o the nuclear target, described as Lorentz-contracted shockwave. We explicitly compute the three-parton Fock space components of the light-cone wave function of the incoming quark and also the production state, which describes the scattering between this dressed quark state and the shockwave for the purposes of computing particle production. This production state is also an ingredient for other interesting calculations, like the next-to-leading order correction to the cross-section for the production of a pair of jets.

MONTE CARLO TRACK STRUCTURE SIMULATION IN STUDIES OF BIOLOGICAL EFFECTS INDUCED BY ACCELERATED CHARGED PARTICLES IN THE CENTRAL NERVOUS SYSTEM

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The study of evaluating radiation risk on the central nervous system induced by accelerated charged particles is very complex and challenging task in modern radiobiological research. Recent radiobiological experimental studies at particle accelerators have shown that the radiation-induced hippocampus injury leads to various behaviour and cognitive changes. In this regards, the development of theoretical models and computer simulation methods of radiation-induced structural and functional variations in the hippocampus is of great interest.

The present work investigates the influence of charged particles on the hippocampal cells of the rat brain using the Geant4 Monte Carlo radiation transport code. The applied computer simulation provides a method for simulation of full physical processes and chemical reactions in developed model of the rat hippocampus, which contains different types of neural cells – pyramidal cells of the cornu ammonis and granule cells of the dentate gyrus, as well as heterogeneous populations of interneurons and neural stem cells. Particle track simulations were made for beams of protons and heavy ions with different energies and doses corresponding to real fluxes of galactic cosmic rays. The distribution of stochastic energy depositions and production of oxidative radical species were obtained and analyzed in different components of the hippocampal cells after irradiation. In result we obtained that the number of injured neurons in the dentate gyrus region is larger than the number of injured neurons in the cornu ammonis region of hippocampus after irradiation with different charged particles.

The precise quantification of the neuron initial damage can be of great importance for both radiation protection, particularly in deep-space long-term manned missions, and radiation treatment of cancer cells.

HADRON MODIFICATION IN DENSE BARYONIC MATTER

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Starting with the Strongly Correlated Quark Model of a hadron structure, SCQM, we demonstrate how the properties of mesons and baryons are modified in hot and dense nuclear environment. It is shown that at these conditions nucleons are converted into delta-isobars and hyperons, and mesons are produced predominantly in vector states. Moreover, the masses of mesons consisting of light quarks changes drastically. These in-medium modifications can lead to the observable effects in heavy ion collisions, especially in NICA energy range, such as enhancement of strangeness, like “horn-effect”, and enhancement of dilepton yield which is related to broadening and dropping of vector meson masses.

MEDIUM-INDUCED MODIFICATION OF KAONS SPECTRA MEASURED IN SIDIS AT HERMES

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The predicted high sensitivity of the nuclear modification factor for K^- in SIDIS in respect to the medium-induced flavour conversion is studied at HERMES experiment. Unlike π^+, π^- and K^+ nuclear modification factor for K^- is assumed to increase at high value of Bjorken variable x_{Bj} and a hadron fraction energy z. The experimental signature of this phenomenon is an enhanced K^- yields compared with those of K^+ for high x_{Bj} and z range. This is consequence of parton energy loss of the leading quarks. The x_{Bj} spectra of nuclear attenuation ratios for charged pions and kaons will be presented in different slices of z extracted on Ne, Kr and Xe targets.

PROGRESS IN EXPERIMENTAL STUDIES AT THE BGO-OD COLLABORATION AT BONN

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for BGO-OD collaboration

Institute for Nuclear Research RAS, Moscow

Recent experimental results and perspectives of the BGO-OD collaboration are presented. Main attention is paid to investigation of formation and decay of baryonic states of possible multi-quark structure, i.e. beyond the minimal 3-quark structure, by means of photoproduction of strange mesons. Experimental facility is described in detail. Also, perspectives to study multifragmentation of light nuclei by intermediate energy photons are discussed.

RECENT FLOW AND FEMTOSCOPY RESULTS FROM STAR

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Relativistic heavy-ion collisions allow to explore the properties of the hot and dense medium known as the Quark-Gluon Plasma. The created matter expands, cools and freezes out to the final-state particles. Azimuthal anisotropy and femtoscopy measurements provide information about collectivity and dynamics of the created medium. Data from the beam energy scan enables STAR to search for the turn on/off signatures of the QGP, for the first-order phase transition, and to constrain various models. In this talk, recent femtoscopy and azimuthal anisotropy results will be presented.

ELECTROCOUPLINGS FOR LOW LYING NUCLEON RESONANCES FROM A LIGHT FRONT QUARK MODEL

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Last decade has been marked by significant progress in the experimental study of low-lying baryonic resonances (the radial/orbital nucleon excitations with $J^P = \frac{1}{2}^{\pm}$, $\frac{3}{2}^{-}$, $\frac{5}{2}^{-}$). The new data on electromagnetic (transition) form factors provide important information on hadron dynamics. Hadron quantum numbers are remarkably consistent with the non-relativistic quark model spectrum, but the traditional quark model refers only to the rest frame, whereas decay and scattering processes require a description of hadrons in motion. This may be accomplished using Light-Front (LF) wave functions. Such approach implies the construction of a good basis of quark light-front configurations possessing the definite value of the total angular momentum $J = L + S$ and satisfying the Pauli exclusion principle. Our approach is to fit parameters of light-front quark configurations to the elastic nucleon form factors extracted from recent data on polarised electron scattering and to use these to calculate the transition form factors at large Q^2 [1].

Contributions of Fock states beyond $|qqq\rangle$ necessarily exist for relativistic dynamics, and may be described either in the quark-gluon ($|qqq\,q\bar{q}\rangle$, ...) or hadron ($|MB\rangle$, ...) bases. Each basis is presumably complete, so $|qqq\,q\bar{q}\rangle + |MB\rangle$ raises issues of double counting. A complementarity between the hadron and quark bases is observed in the data and called "duality", but its origins remains unclear. In Refs. [1, 2] we considered the lightest nucleon resonances $N^*(1440)/N^*(1535)$ as a mixed state of the radially/orbitally excited quark configurations sp^2/s^2p and the "hadron molecules" (a loosely bound states $N\sigma/\Lambda K$ respectively). The two-component model allows to describe with reasonable accuracy the recent CLAS electroproduction data at moderate Q^2 and predict the behaviour of helicity amplitudes at more high Q^2 (see our preliminary results in Ref. [2]). Comparisons between model and form factor data indicate that the higher Fock states contribute mainly for $Q^2 < 2 - 3$ GeV^2, whereas "quark core" $|qqq\rangle$ states remain at higher Q^2. It allows to evaluate the weight of the quark core in the resonance and to show that Higher Fock states appear to be enhanced for radial excitations such as the Roper $N^*(1440)$. Here we consider a generalisation of our model for the states of the 70^- multiplet.

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QUANTUM SPIN DYNAMICS IN EXTERNAL CLASSICAL FIELDS

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Understanding the dynamics of fermion particles with dipole moments (electrons, protons, neutrons, neutrinos) in arbitrary electromagnetic, gravitational and inertial fields is important for many high-energy and astrophysical problems. We study the classical and quantum dynamics of spinning particles with dipole moments in the framework of the general-relativistically covariant Dirac theory. The exact Foldy-Wouthuysen transformation for the most general case of a fermion in arbitrary configurations of superimposed strong gravitational (inertial) and electromagnetic fields is derived. These results are used to obtain the quantum and quasiclassical equations of motion of fermion particles. We demonstrate the complete consistency of the quantum and classical dynamics. Physical applications in high-energy physics are discussed, in particular, spin effects in the gravitational wave are analysed.

FIRST EXPERIMENTS FOR DEEP IONISATION OF Ir, Ce AND Xe ATOMS IN A LOCAL ION TRAP IN JINR

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The results of the production of High Charge ions Ir, Ce and Xe in the MaMFIS (Main Magnetic Focus Ion Source) [1] are presented. Ionization occurs in local ion traps of a pulsating electron beam, where the current density can reach extremely high values (~10 kA/cm^2). The electron current reaches 50 mA at an energy of an accelerating potential of 40 kV.

The ion charge was determined by X-ray spectroscopy. M-shells of the Ir, Ce were completely ionized, and L-shells of the Ce and Xe partially. At the same time, the ions Ir62 +, Ce50 + were confidently identified (Fig. 1).

The efficiency of ionization is not inferior to existing superconducting ionizers of the "Livermore EBIT" type. Ionizer MaMFIS can be used to solve modern high-tech physical problems, in particular in surface physics, microplasma physics, in devices for single ion implantation, etc.

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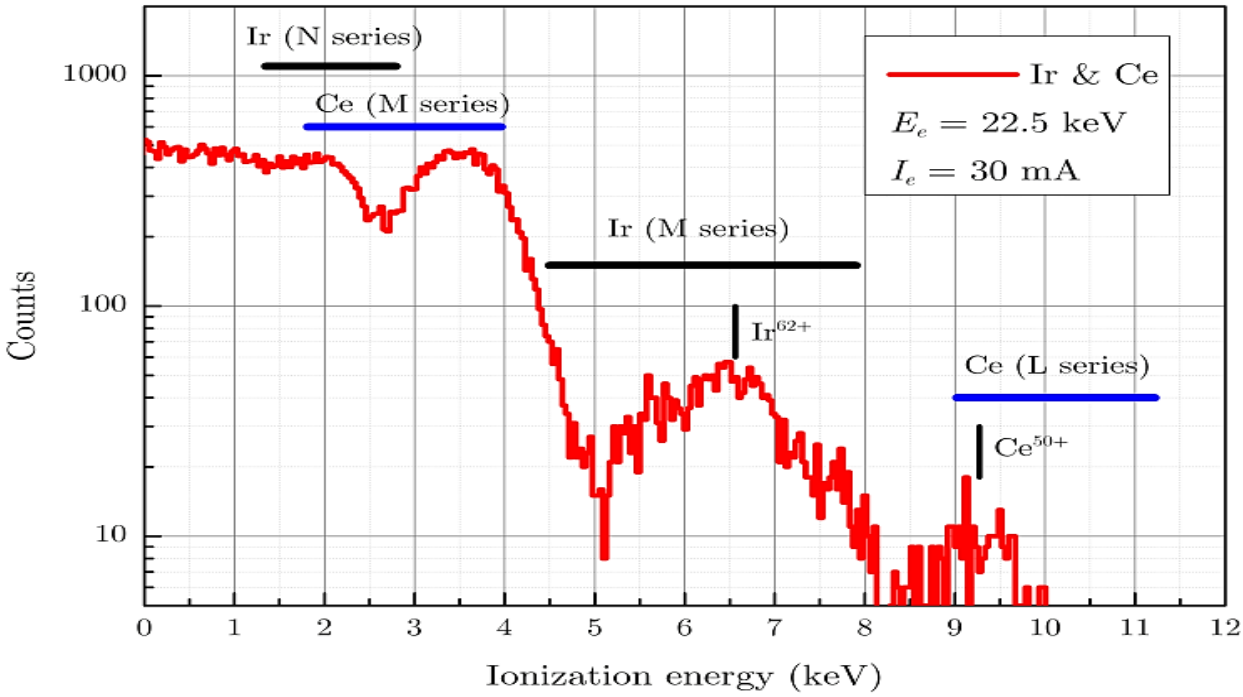

Fig. 1. X-ray spectrum due to radiative recombination of Ir and Ce ions (cathode materials) with the beam electrons. The ionization energy is defined as difference between the energy of emitted photons and the electron beam energy E_e = 22.5 keV.

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EXOTIC QUARKONIUM AT E+E- COLLIDERS

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We present recent results on exotic quarkonium in e+e- annihilation. We discuss the status of both exotic charmonium and bottomounium searches. Our review covers new results from Belle, BaBar, BESIII Collaborations and discussion of perspectives for future experiments such as Belle-II and Super-Tau-Charm factory in Novosibirsk.

COMPARISON OF TWO DIFFERENT DESCRIPTIONS OF THE V-I CHARACTERISTIC OF GRAPHENE: THEORY AND EXPERIMENT

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The formalism of the nonperturbative description of transport phenomena in graphene within the framework of a quantum kinetic equation for the Schwinger-like process [1, 2] is compared with the description on the basis of Zener-Klein tunneling [3, 4] and experimental data [5]. The regime of ballistic conductivity in a constant electric field is considered.

In the latter case [3, 4] the interaction of carriers with electric field is described in terms of the spatial dependence of their potential energy (x-representation). For the constant electric field under consideration $eV(x) = -eEx$. The presented kinetic formalism uses an alternative method of describing the interaction with a field through the introduction of a quasimomentum $P = p-(e/c)A(t)$ where $A(t)$ is the vector potential (t-representation). Both approaches should lead to the same physical characteristics of the described process. But measuring the current in the experiment [5] corresponds to the x-representation and is realized under static conditions determined by the potential difference between the electrodes and the distance between them. On the contrary, in the approach based on the t-representation it is necessary to introduce the effective lifetime of the generated carriers. This time depends on the distance between the electrodes but this dependence is not trivial.

We give a detailed comparison of these two descriptions of the current and demonstrate a good correspondence with the experimental data of the alternative approach based on the t-representation. This provides a reliable foundation for the application of the nonperturbative methods adopted from the strong field QED (exact solutions [6, 7], kinetic approach [8, 9]), that allows to include in the consideration more general models of the field (arbitrary polarization and time dependence) and to extend the scope of the theory.

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BEAM AND TARGET OPTIMIZATION FOR ENERGY PRODUCTION IN ACCELERATOR DRIVEN SYSTEMS

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The new concept of light nuclear beams instead of proton beams for ADS is substantiated.

The energy efficiency is characterized by the energy gain calculated as the ratio of the energy released in the target to the energy spent for the beam acceleration. The energy deposited in the target is obtained viaGeant4 simulation. The energy spent for the beam acceleration depends on the particle type and energy, beam intensity, and accelerator type (synchrotron, linac, cyclotron). A method to calculate the energy spent for the beam acceleration by scaling from the data for a reference beam is presented.For a given beam, the highest energy gain is obtained when the beam is accelerated in a synchrotron. A synchrotron, however, cannot ensurethe beam intensities necessary for accelerator driven systems (ADS). Linacs are capable to produce the required beam intensities with good energy gain. For this reason, we consider the beams accelerated in a linac in the further analysis.

The influence of the target structure on the energy efficiency of 0.5-4 GeV proton beams and 0.25 – 0.5 AGeV light ion beams is studied. The target consists of rods withdifferentcomposition (metal, oxide, carbide) and different levels of enrichmentin order to implement the target with a criticality coefficient of 0.96 -0.97, which ensure safe operation. The influence of the rod diameter and the distance between rods was investigated. The cooling with different metals(lead, lead-bismuth eutectic-LBE, and sodium) is compared. The use of convertors from heavy metals (uranium, lead, tungsten) and very light materials (lithium, beryllium, carbon) and their influence on the neutron spectrum and energy released are analyzed.

Our studies yield the conclusion that the best solution for ADS from the point of view of the energy efficiency and miniaturization is as follows: beams of Li-7 and Be-9 with energies of 0.35 - 0.4 AGeV, cooling with lead or LBE, and the use of convertors from Be or Li.

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PERFORMANCE FOR ANISOTROPIC FLOW STUDIES AT MPD (NICA)

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Multi-Purpose Detector (MPD) experiment at NICA collider has a potential of discoveries in the area of QCD phase diagram with high net baryon densities and moderate temperatures. Anisotropic transverse flow is one of the key observables to study the properties of matter created in heavy-ion collisions. MPD performance for anisotropic flow measurements is studied with Monte-Carlo simulations of gold ions at NICA energies $\sqrt{s_{NN}} = 4 - 11$ GeV using different heavy-ion event generators. Different combinations of the MPD detector subsystems are used to investigate the possible systematic biases in flow measurement and to study effects of detector azimuthal non-uniformity. Resulting performance of the MPD for flow measurements will be demonstrated for directed and elliptic flow of identified charged hadrons as a function of rapidity and transverse momentum in different centrality classes.

RELATIVISTIC LOCAL EQUILIBRIUM STATISTICAL MECHANICS AND THE TRANSVERSE MOMENTUM DISTRIBUTIONS OF HADRONS

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The modern relativistic thermodynamics of a moving body has two different formulations: the Planck's and Ott's formalisms. They differ by the form of the Lorentz transformation of temperature. In this paper we demonstrated that the Planck's formalism is only correct and the Ott's formalism is not valid because it violates the Legendre transform and the other relations of relativistic dynamics. We introduced the relativistic cells model on the base of the Planck's formalism of the relativistic statistical mechanics under the assumption of the local equilibrium and apply it to describe the experimental data on the transverse momentum distribution of hadrons created in the heavy-ion and proton-proton collisions at high energies. In this model the topological forms of the spatial fireball and the speed filed of cells are given by definition. In the case of the spherical fireball, for the speed of cells we considered two scenarios: (1) the speed sphere with the spherical Hubble expansion and (2) the speed spheroid with the longitudinal Hubble expansion and transversal radial explosion. However, in the case of the spheroidal fireball, for the speed of cells we considered only the spheroidal Hubble expansion.

EXCLUSIVE STUDIES OF SHORT RANGE CORRELATIONS IN NUCLEI

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Short Range Correlations (SRC) are brief fluctuations of high relative-momentum nucleon pairs. Properties of SRCs have important consequences for nuclear physics, high energy physics, atomic physics, and astrophysics. SRC pairs form some of the most dense states of cold matter achievable on earth, making them an ideal system to study the interplay between partonic and nucleonic degrees of freedom in nuclear systems.

Current SRC studies focus primarily on exclusive breakup reactions, where high-energy probes are used to break up SRC pairs, and specialized detectors measure all of the particles emitted in the reaction. These experiments allowed us to quantify properties of SRC pairs (isospin decomposition, nuclear mass and asymmetry dependence, c.m. momentum distribution) and to propel the elusive short-range part of the nuclear interaction.

Jefferson Lab plays a key role in the SRC program. CLAS (CEBAF Large Acceptance Spectrometer), located in Hall B at JLab, has almost 4pi coverage and is capable of measuring exclusive reactions of the type A(e, e'pp). CLAS uses electron beam with energy of 4-5 GeV and a set of nuclear targets (d, He-3, He-4, C-12, Al-27, Fe-56, and Pb-208). An important advantage of the CLAS experiments is that it has an open e e trigger allowing to look for different signatures in the stored data.

We will discuss the recent experimental results from Jefferson Lab and future experiments planned at Jefferson Lab as well as at JINR.

SPIN AS AN INTRINSIC FORM OF TOP ANGULAR MOMENTUM

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The idea of spin as an intrinsic form of orbital angular momentum on the fundamental (field-theoretical) level was realized by Pauli and Dirac. It will be demonstrated that the idea of spin as an intrinsic form of top angular momentum can be realized as well and, hence, the fundamental idea of electron spin of Kronig, Uhlenbek and Goudsmit can be presented as an intrinsic form of symmetric top rotation motion. It will be shown that symmetry of intrinsic top can be realized on a set of the simplest geometrical quantities, which themselves do not exhibit this property. That is why an intrinsic form of top angular momentum will be called emergent spin. The theory of field that carries emergent spin (emergent spin field) can be considered as a dual realization of the Standard Model derived from the first principle.The local internal transformations, which allows to consider the emergent spin field as a system and spin as its emergent property, form a group of general linear transformations. It can be shown that emergent spin is a bipolar structure on this group. The bipolar structure means that the two dual sets of commuting operators exist which define the Lie algebra of the group in question and its two dual e The transformations of these subgroup commute with each other and subgroup S and S. the emergent spin field is the space of their two-valued representation. The emergent spin field describes the physical entity retaining the elementarity and is considered to be characterized by its equation and the electrical charge in one case and the pseudocharge, electric charge, neutrino charge in the other case. The neutrino charge is a new quantum number that is tightly connected with the orientation of space (neutrino charge exists if space is orientable). This explains the pairing of the electron and neutrino in the Standard Model. Comparing the equations of emergent spin field with the Dirac equation, one can conclude that in the case of the Dirac equation the symmetry of intrinsic top is violated and as a consequence new interactions and new quantum number (neutrino charge) are lost. From the concept of the natural time, formulated earlier, it follows that there are particles with properties of a symmetric top. We put forward idea that particles of such kind correspond to the particles of the Standard Model known as quarks. By this the unusual properties of quarks do get the natural explanation. The observed generations of quarks and leptons can be considered in this case as different states of the particle that we put in correspondence to the complex emergent spin field and the number of these generation equals four. The concept of emergent spin is more general than the concept of Pauli and Dirac spin and, hence, it can be interesting in terms of discussion of the possible ways to look for a physics beyond the Standard Model. In this context it should be mentioned that concept of emergent spin is tightly connected with gravity.

DIFFRACTIVE DATA FROM THE LHC AND THEIR PHYSICAL IMPLICATIONS

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Experiments undertaken by the LHC collaborations TOTEM and ALPHA/ATLAS in revealed new interesting phenomena which have posed questions on their physical meaning. From general consideration these phenomena are related to the large distance behavior of underlying quantum fields. In this review talks I will exhibit our present (mis)understanding of these data and problems which confront the theory.

ANALYTICAL CALCULATION OF PHASE-SPACE INTEGRALS IN MASSLESS QCD

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We present results of our calulation [1] of five-particle phase-space integrals in massless QCD. Analytical results for the integrals are obtained using Dimensional Recurrence Relations. Dicussed technique used for phase-space integrals evaluation and its extension for calcualation of the integrals with virtual corrections.

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MEASUREMENT OF ANALYZING POWERS FOR NEUTRONS SCATTERING ON CH2, CH, C AND CU TARGETS AT THE MOMENTA FROM 3.0 TO 4.2 GEV/C

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Analyzing powers for polarized **neutrons** have been measured only for thin hydrogen targets. Cross sections and analyzing powers for np, for both elastic scattering and charge exchange are known up to 29 GeV/c. No data exist for thick analyzers.

During two beam runs in the years 2016 and 2017, the analyzing powers for protons and neutrons scattering on CH2, CH, C and Cu targets were measured at the nucleon momentum from 3.0 to 4.2 GeV/c with the ALPOM2 setup at the Nuclotron accelerator. The data for polarized neutron beam are obtained for the first time, thanks to the unique polarized deuteron beam that is presently available up to 13 GeV/c.

The measurement of the angular dependence of Ay for the neutron is essential to the continuation of the neutron form factor measurements to the highest possible transferred momentum-Q^2 at the Jefferson Laboratory. The reaction p+Cu(W), with the detection of a neutron in the forward direction by a hadron calorimeter, can be used for the measurement of the proton polarization at the future NICA collider.

HYPERONS AT BM@N EXPERIMENT: FIRST RESULTS

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BM@N (Baryonic Matter at Nuclotron) is the first experiment to be realized at the accelerator complex of NICA-Nuclotron at JINR (Dubna). The aim of the experiment is to study interactions of relativistic heavy ion beams with a kinetic energy from 1 to 4.5 AGeV with fixed targets. Some results of the analysis of minimum bias experimental data on interactions of the deuteron and carbon beams at 4 AGeV with different targets collected during technical runs are presented. Preliminary results on the data processing from the first physical run with argon beam are also shown and discussed.

PSEUDORAPIDITY DEPENDENCE OF MULTIPLICITY AND TRANSVERSE MOMENTUM FLUCTUATIONS AT THE SPS ENERGIES

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A search for the critical behavior of strongly interacting matter was done by studying the event-by-event fluctuations of multiplicity and transverse momentum of charged hadrons produced in inelastic p+p collisions at 20, 31, 40, 80 and 158 GeV/c beam momentum and central Be+Be collisions at 150A GeV/c at the NA61/SHINE experiment. Results for energy dependence of the scaled variance of the multiplicity distribution [1] and for two families of strongly intensive measures [2] of multiplicity and transverse momentum fluctuations $\Delta[P_T, N]$ and $\Sigma[P_T, N]$ are presented. These strongly intensive quantities are assumed to be independent both of the reaction volume and of the trivial fluctuations of the volume. Therefore, one may expect much higher sensitivity in the search of the critical point. The study was performed in different pseudorapidity regions, which corresponds to changing the rapidity averaged baryo-chemical potential and the value of temperature at the freeze-out stage. The strongly intensive measure $\Sigma[N_F, N_B]$ [3] is used in the analysis of short- and long-range multiplicity correlations and is considered to be sensitive for the initial conditions of particle production such as string fragmentation and fusion.

Results on multiplicity and transverse momentum fluctuations significantly depend on width and/or location of pseudorapidity intervals. Monte Carlo event generator EPOS1.99 describes well the data for the $\omega[N]$ and $\Sigma[P_T, N]$ measures. However, a significant discrepancy between data and EPOS1.99 is observed for $\Delta[P_T, N]$ at all collision energies both for p+p and Be+Be collisions. The deviation grows with the pseudorapidity window width. Results for forward-backward correlations in terms of strongly intensive quantity $\Sigma[N_F, N_B]$ calculated in EPOS1.99 are in a good agreement with data. An increase of the value of $\Sigma[N_F, N_B]$ with the distance between forward and backward pseudorapidity intervals corresponds to the predictions of model of independent quark-gluon strings [4].

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INFLUENCE OF MEDIUM NONSTATIONARITY ON AXIAL CURRENT

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Polarization of particles is closely related to their axial charge, which they can acquire due to the chiral effects associated with the nonstationary motion of the medium. We calculate the axial current for a medium with local rotation and acceleration, consisting of weakly interacting fermions in a state of local thermodynamic equilibrium based on two different approaches. In the first of the approaches, the properties of such a medium are described using the covariant Wigner function. A formula for an axial current is derived outside perturbation theory, and it leads to the Chiral Vortical Effect in the limiting case. In the resulting formula, the chemical potential μ, angular velocity Ω and the acceleration a appear in the combination $\mu \pm (\Omega \pm ia)/2$. At zero temperature, the axial current, depending on the angular velocity and chemical potential, is suppressed in a two-dimensional plane region, which also means suppression of polarisation. In the second approach, the hydrodynamic coefficients in the axial current are calculated on the basis of the equilibrium quantum statistical density operator in the third order of perturbation theory in thermal vorticity. It is shown that the approaches of the Wigner function and the statistical density operator lead to the same result in describing effects associated only with vorticity when the local acceleration is zero, but differ in describing mixed effects for which both acceleration and vorticity are sufficient simultaneously. On the basis of the obtained formulas for the axial current, the correspondence of various approaches to the calculation of polarization of baryons is justified.

RECENT RESULTS FROM PHENIX AT RHIC

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The PHENIX experiment at the relativistic heavy ion collider (RHIC) has finished data taking in 2016. However, huge datasets taken in different collision systems (p+p, p+A and A+A) at different energies ($\sqrt{s_{NN}}$ = 19-500 GeV) in the last years of the detector operation are actively analyzed by the collaboration and bring a wealth of new experimental results. In this talk, we present review of the most recent PHENIX results on the light and heavy flavor hadron production, yields and angular correlations of the direct photons in heavy-ion collisions as well as on search for onset of collectivity in high multiplicity p+p and p+A collisions.

INVESTIGATION OF THE FRACTAL PROPERTIES FOR THE MULTIPARTICLE EVENTS IN HEAVY ION COLLISIONS

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The method of the Higuchi's fractal dimension estimation is applied to the events distribution on the maximum transverse momenta. In this case the maximum transverse momentum is the global variable characterized the event as a whole and particles distribution in the event. Study of such distribution could reveal the features of the physics for particle production.

INVESTIGATION OF THE ELECTROMAGNETIC CALORIMETER RESPONSE FUNCTION BY COSMIC MUONS

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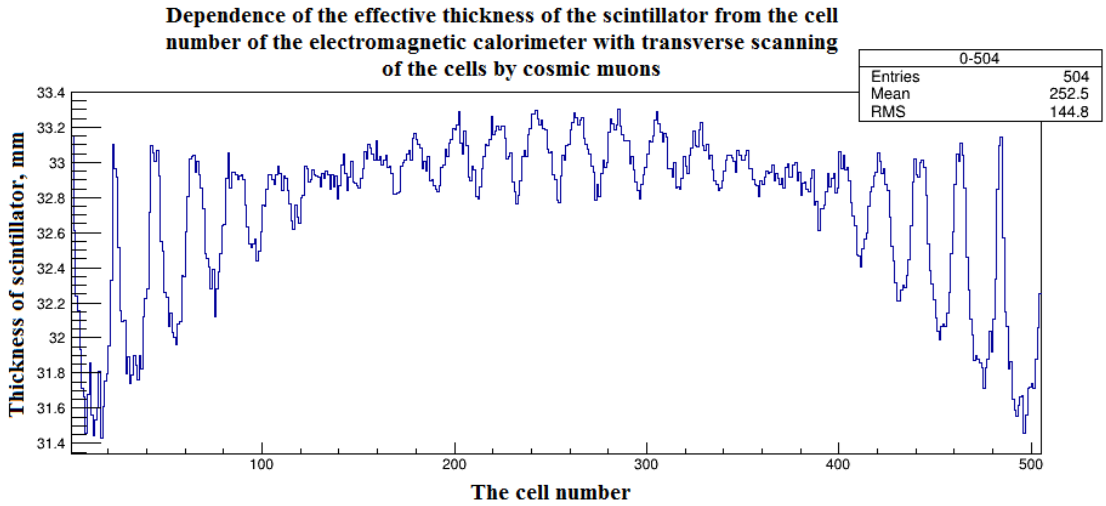
In this work, the passage of cosmic muons in calorimetric modules was simulated [1]. The coefficients for converting signal amplitudes into absorbed energy of a passing particle were obtained. The data collected during the exposure of the electromagnetic calorimeter to cosmic muons were analyzed. The results of the analysis were used to process the experimental data obtained in the interaction of carbon, argon and krypton at 3.5 GeV/nucleon energy with different targets.



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OFF-SHELL INITIAL STATE EFFECTS IN DRELL-YAN PROCESS AT HADRON COLLIDERS

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Precise theoretical and experimental study of angular distributions of Drell-Yan leptons, produced in pp-collisions, demonstrates the important role of initial-state interactions and influence of intrinsic transverse momenta of initial-state partons. If annihilating initial-state quark and anti-quark have transverse momenta they should be off-shell. The one way to preserve gauge-invariance of scattering amplitudes in all orders of perturbative QCD is consideration of initial-state partons as Reggeized partons which are constituents of Lipatov's effective theory. In this talk we present results of calculations of invariant mass, transverse momentum spectra of Drell-Yan lepton pairs and virtual-photon polarization observables in unpolarized pp-collisions at the energy range of NICA collider which were obtained in the Parton Reggeization Approach [1, 2, 3, 4]. The properties of Boer-Mulders function in Parton Reggeization Approach will be also discussed.

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PENTAQUARK AND HYBRID STATES

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The LHCb pentaquark states have been shown to be described by several models: as compact or molecular states or even very recently as molecolar states with a core.

A review of different models and different predictions will be given and they will be compared. Moreover new predictions for the most intresting channels where to look for new pentaquark states will be discussed, as it can be intresting also for the experimentalists. Finally, the lowest supermultiplet of charmonia hybrids- as predicted for the first time in Ref.[1]- will be presented and a possible experimental hybrid candidate, i.e. the Y(4260), will be discussed.

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BOUND STATE DESCRIPTION IN QED: ALTERNATIVE FIELD-THEORETICAL APPROACH

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We will present a field-theoretical method to construct in a consistent way relativistic (Hamiltonian) interactions in QED. In particular, the interaction operators for processes of the type $e^-e^- \to e^-e^-$, $e^-e^+ \to e^-e^+$, $e^-e^+ \leftrightarrow 2\gamma$, $\gamma e^- \to \gamma e^-$ are derived on one and the same physical footing. The method is based on the unitary clothing procedure [1,2] (cf. [3]) which introduces a new representation of the primary total Hamiltonian in terms of the operators for creation and destruction of the so-called clothed particles, viz., those particles that can be observed. Within the approach all interactions constructed are responsible for physical (not virtual) processes in a given system of interacting fields. Such interactions are Hermitian and energy independent including the off-energy-shell and recoil effects (the latter in all orders of the v^2/c^2 - expansion). The persistent clouds of virtual particles are no longer explicitly contained in the clothed-particle representation (CPR), and their effects are included in the properties of the clothed particles (electrons and positrons) and interactions between them. The QED Hamiltonian H in the CPR and the e^-e^+ interaction operators in the e^2 - order are employed when finding the simplest H-eigenvectotrs with the positronium (Ps) properties. The Ps ground state is determined by the so-called three-dimensional convolution formula (cf. Eqs. (1.8) in [4] and (12.303) in [5]) similar to that for the deuteron state from [1]. In this context we are drawing parallels with our calculations of the S and D components of the deuteron wave function (WF) where all constituents are on their mass shells. Starting from the well-known K - shell WF in the Coulomb field as the lowest-order approximation to the Ps WF we obtain a perturbative expansion. We will show our calculations of the corresponding relativistic and off-energy-shell corrections.

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MULTIQUARK CONFIGURATIONS IN BARYONS AND NUCLEI

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The recent decade researches has shown increasing need to include the multi-quark configurations into consideration to describe such phenomena as: the production of hadrons in high p_T ($p_T > 1$ GeV/c) region in PP-, PA- and AA-collisions; discovery tetraquarks and pentaquarks; investigation of cumulative processes and others. We discuss the experimental programs of research at new installations which will be created at the nearest time SPD (NICA, Dubna) and PANDA (FAIR, GSI). These investigations should give unambiguous prove of existence the multiquark configurations and should determine their properties.

ANGULAR CORRELATIONS IN GAMMA + 2 JET EVENTS AT HIGH ENERGIES IN THE PARTON REGGEIZATION APPROACH

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A study of correlation observables provides a good test for perturbative QCD (pQCD) because of its sensitivity to emissions of additional partons. Moreover, the prompt production of photon in a hard process is suitable for probing pQCD due to an absence of nonperturbative effects of hadronisation. In the present work we investigate in the Parton Reggeization Approach (PRA) the process of prompt photon production associated with two jets within the kinematical conditions of the Tevatron and consider the interplay of single and double parton scattering contributions. PRA is based on the high-energy factorization in the multi-Regge regime [1, 2] and on the Lipatov's effective field theory for Reggeized gluons and Reggeized quarks [3, 4] .

Considering the single parton scattering (SPS) we take into account all the $2 \to 3$ subprocesses in the PRA with two Reggeized particles, quarks or gluons, in the initial state. For the first time we have calculated analytically the amplitudes accordingly to Feynman rules of the PRA [5], using the model file ReggeQCD [2] for the package FeynArts [6]. We strongly proved the gauge invariance of all the amplitudes and then calculated the squared matrix elements. We demonstrate the subprocess $QR \to qg\gamma$, where $q = u, d, s$ to give the main contribution in the SPS mechanism. In the double parton scattering (DPS) we consider the convolution of the all combinations of $2 \to 1$ and $2 \to 2$ subprocesses of PRA with Reggeized partons in the initial state.

Taking into account the single and double parton scattering processes in the PRA we reproduce well the azimuthal angle differences spectra at the Tevatron [7] in the different ranges of transverse momenta of the subleading jet, and achieve the same degree of agreement as parton model calculations at the NLO level. We demonstrate the DPS to give the dominant contribution in the region of small azimuthal angle differences.

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FEATURES OF RADIATION OF RELATIVISTIC ELECTRONS IN STORAGE RINGS

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The formulation of the problem is due to the fact that the spectral properties of radiation in alternating magnetic fields, as compared with homogeneous fields, differ little, but the angular characteristics depend significantly on betatron oscillations. The dynamics of an electron in the magnetic systems of accelerators is quite complicated, so a number of simplifications have been made here. The asymptotic formulas for the spectral and angular distributions of the radiation intensity with the first quantum correction are oblained by Schwinger's operator method.

For them, as well as for the angular characteristics of synchrotron light, approximate expressions are given, allowing researchers to determine the desired properties of emission at certain points of the orbit. In addition, on a particular example for radition problems, the solution of the Hill equation by the methods of Whittaker and stretched parameters is considered in the linear approximation. As a result, it was revealed that the degree of polarization of the radiation and the angular properties are essentially affected by vertical vibrations of electrons; this coincides with the available experiments. The beam effect is determined by the fact that the averaging over the phases of the electron oscillations is carried out and the mean-square amplitudes are taken into account.

PREDICTION OF THE PARTICLE PRODUCTION IN PP COLLISIONS WITH THE MPD DETECTOR AT THE NICA COLLIDER

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The proton-proton collisions have been extensively used as a baseline reference for nucleus-nucleus collisions. In this work, Monte Carlo simulations of pp collisions at $\sqrt{s}$ = 4–25 GeV were performed to study the possibilities of the Multi–Purpose Detector (MPD) to register data from small systems at the energy range of NICA. For that purpose EPOS 1.99 was used as particle generator and the MpdRoot code to simulate and reconstruct the generated data. The production of identified protons, pions and kaons from pp collisions was studied through their mean multiplicity, rapidity spectra and particle ratios as function of the collision energy. The production of Λ hyperons was also estimated. The comparison with recent data from NA61/SHINE experiment is presented.

DYNAMICS OF A TENSOR POLARIZATION OF PARTICLES AND NUCLEI AND ITS INFLUENCE ON THE SPIN MOTION IN EXTERNAL FIELDS

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The tensor polarization of particles and nuclei becomes constant in a coordinate system rotating with the same angular velocity as the spin, and it rotates in the laboratory frame with the above angular velocity [1]. The general equation defining the time dependence of the tensor polarization is derived. An explicit form of the dynamics of this polarization is found in the case when the initial polarization is axially symmetric. It is shown that the spin tensor interactions result in mutual transformations of the vector and tensor polarizations and do not rotate the spin. Nevertheless, the spin tensor interactions can influence the angular velocity of spin rotation in some cases.

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DYNAMICS OF AN ORBITAL POLARIZATION OF TWISTED ELECTRON BEAMS IN ELECTRIC AND MAGNETIC FIELDS

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Relativistic classical [1] and quantum [2] dynamics of twisted (vortex) Dirac particles in arbitrary electric and magnetic fields is constructed. This allows us to change the controversial contemporary situation when the nonrelativistic approximation is used for relativistic twisted electrons. The relativistic Hamiltonian and equations of motion in the Foldy-Wouthuysen representation are derived. Methods for the extraction of an electron vortex beam with a given orbital polarization and for the manipulation of such a beam are developed. A critical experiment for a verification of the results obtained is proposed. The new effect of a radiative orbital polarization of a twisted electron beam in a magnetic field resulting in a nonzero average projection of the intrinsic orbital angular momentum on the field direction is predicted.

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DEUTERON BREAKUP AT ZERO ANGLE IN THE COULOMB NUCLEAR FIELD

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Additional analysis of data, presented earlier [1], has performed. The investigated reaction was

$$d + A \to Z1 + X,$$

where $Z1$ is charged particle, mostly a proton. Due to high precision of measuring of transversal momentum of $Z1$, $p_t = p \sin\theta$, where p is deuteron momentum, the dependence of ratio $^{12}C/^{1}H$ on p_t was investigated. The results are presented in Fig.1.

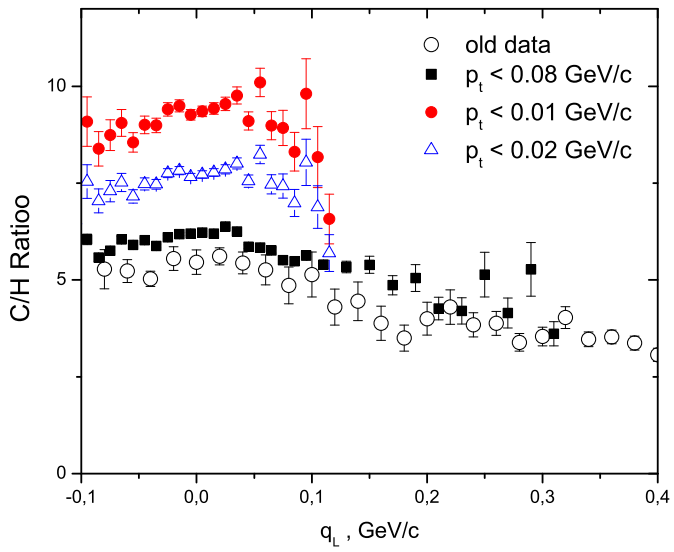

Figure 1: Ratio $^{12}C/^{1}H$ cross sections at different transversal momentum regions.

Here q_L is a longitudinal momentum of the proton in the deuteron rest frame.

Sharp enlarging of the ratio at small p_t we view as a manifestation of deuteron breakup in the Coulomb field of the nucleus.

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DEUTERON BEAM POLARIMETER AT NUCLOTRON INTERNAL TARGET

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The current deuteron beam polarimetry at Nuclotron is provided by the Internal Target polarimeter based on the use of the asymmetry in dp-elastic scattering at large angles in the c.m.s. at 270 MeV. The upgraded deuteron beam polarimeter has been used to obtain the vector and tensor polarization during 2016/2017 runs for the DSS experimental program. The polarimeter has been used also for tuning of the polarized ion source parameters for 6 different spin modes. The report contain vector and tensor polarization values. The data analysis has been performed using developed software based on C++ language and ROOT5 library.

EXOTIC HADRONS WITH HEAVY QUARKS: EXPERIMENTAL PERSPECTIVE

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B-factory, charm-factory and hadron-collider experiments have produced evidence for a large number of heavy hadronic structures with unusual properties. We will discuss their experimental signatures, together with underlying uncertainties and future prospects for improvement.

A NEW APPROACH TO THE LONGITUDINAL ELECTROMAGNETIC CASCADES DESCRIPTION IN HEAVY AMORPHOUS SEGMENTED MATERIALS

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Although the process of electromagnetic cascades (EMC) created by high energy ($E_\gamma \gtrsim 100$ MeV) gamma quanta (GQ) in heavy amorphous media is known for a long time (for example, [1]), until the present time it is used in practice very simple information about EMC only: three-parameter approximation of their longitudinal profile (LP) and the average relative energy dispersion. Nevertheless, for some advanced applications it is reasonable to better the so far prevailing simple model description [2] and, moreover, to investigate as well the problem of segmentation of EMC registration media in order to find the most favorable one for optimal reconstruction of primary energy of GQ producing EMC.

In the work a five parameter model (1) of longitudinal EMC profile in liquid Xe, BGO and PWO has been introduced and the values of its parameters as a function of E_γ in the range of 200-3500 MeV and for three cut-off energy values of cascades electrons: 0.5, 1.2 and 2.0 MeV determined. For this purpose GEANT4 code was used and 10^4 events for each case were modeled, i.e. $3x3x6x10^4$ histories in total [3].

$$\left(\frac{-dE}{dt}\right) = \alpha (t-\varepsilon)^{\beta} \exp\left(-\gamma t^{\delta}\right) \qquad (1)$$

It has been found that our model satisfactorily approximates all calculated data (see, for example, Fig.1) and available experimental results too. Moreover, it was also found that the segmentation of materials registering EMC in the form of a sequence of layers along the direction of primary GQ is optimal when the layer thickness is equal to Δt=0.5 r.l. (radiation length).

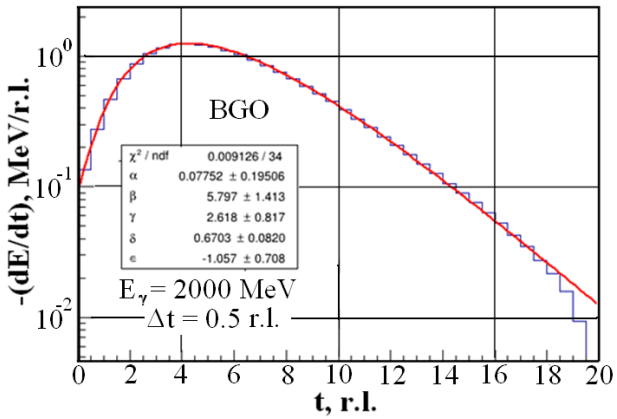

Fig.1. Longitudinal profile of EMC created in BGO by GQ of energy E_γ=2000 MeV. BGO is segmented with a layer of Δt=0.5 r.l. Solid curve demonstrates the approximation function (1). In inlet shown are the corresponding values of its parameters and χ^2/n_{of}.

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CLOSED SYSTEM OF EQUATIONS FOR DESCRIPTION OF THE $e^+e^-\gamma$ PLASMA GENERATED FROM VACUUM BY STRONG ELECTRIC FIELD

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We develop a self-consistent kinetic description of a $e^+e^-\gamma$ plasma, generated from the vacuum in a focal spot of counterpropagating laser pulses. At the moment our model assumes purely time-dependent external (laser) field, but properly takes into account the semiclassical internal (plasma) field, as well as quantum radiation. While nonperturbative kinetic description of e^+e^- pair production from vacuum [1] and the simplest variant of backreaction problem [2] have been previously addressed, quantum radiation is included in such a model for the first time. To achieve this goal we derived coupled kinetic equations for the electron, positron, and photon plasma species and the Maxwell equation for the internal electric field. Photon subsystem is included systematically using the BBGKI chain, which we truncate at second order of perturbation theory by taking into account the annihilation and radiation channels (preliminary consideration of the annihilation channel was previously discussed in [3]). An important application of our results would be consideration of laser field depletion due to cascade production [4] beyond the locally constant field approximation.

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NUMERICAL EVALUATION OF MELLIN-BARNES INTEGRALS USING EFFICIENT APPROXIMATIONS TO THE CONTOUR OF STATIONARY PHASE

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We present the result of the application of a new efficient integration contour for numerical calculation of one-dimensional Mellin-Barnes (MB) integrals, which are widely used in high-energy physics, in the case of a finite asymptotic behavior the corresponding stationary-phase contour in the limit $\mathrm{Re}z \to -\infty$. Such asymptotic behavior is observed, for example, for some MB integrals arising in Feynman diagrams, and in the case of the reconstruction of the DIS structure functions on the basis of its the Mellin moments. The best efficiency in a numerical integration can be achieved on the contour of the stationary phase, where the oscillations of the integrand are minimal. However, the solution of the differential equation for the stationary phase contour and its subsequent an application in the calculation of the MB integral may require big computing expenses.

Recently, significant progress has been made in the efficient computing of MB integrals and it has been shown that a shape of the integration contour by which the integration is carried out is very important [1, 2, 3, 4]. We show that our approximation for the integration contour, the construction of which is quite simple, reproduces the asymptotic behavior of the exact stationary phase contour well, and the use of the proposed contour can provide the required high relative accuracy for the MB integral, say, of the order $\sim 10^{-20}$. Comparison of the efficiency of the numerical calculation of the MB integral using different approximations of the stationary phase contour is discussed.

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DENSE COLD MATTER

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The possibility to study of dense nuclear matter with the density as high as neutron star core and even larger in the laboratory with SPD (NICA) is discussed. Special rare kinematical trigger for relativistic ion-ion collisions is proposed for such study. Expected properties of the matter in such unusual conditions and experimental methods for its study of is discussed.

INVESTIGATION OF THE EFFECT OF COHERENT ELECTROMAGNETIC RADIATION BY RADIOACTIVE DECAY OF ^{239}Np AND ^{152}Eu

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Some experiments, which have been carried out in the frames of "Energy and Transmutation" project and directed to solve tasks of studying the nuclear- physical processes' characteristics, ensuing on nuclei under the influence of coherent electromagnetic radiance, have been discussed in the report. The aim of the experiments / 1, 2 / is to study the mechanisms of influence of electromagnetic radiation of microwave range and laser radiation on the probability of the nuclear decay. A nuclear decay of ^{152}Eu, ^{137}Cs, ^{231}Th, ^{234}Th, 239Np under the influence of laser radiances to their water solutions has been investigated. We have a great interest in studying a well- known and an investigated in details nucleus of ^{152}Eu.

The solution of ^{152}Eu has been under the influence of the laser radiance with wave length of radiation to 1064 nm, pulse repetition frequency to 10 Hz and energy in impulse to 700 mJ. Futher, we have used another laser, with wave length of radiation to 1064 nm, pulse repetition frequency to 10000 Hz and an energy in impulse 1 mJ. It is necessary to note that when we decrease a pulse repetition frequency to 1000 times, but increase the energy of the impulse to 700 times, the common tendency of the decreasing activity is kept (Fig.1).These experimental data have been discussed in the report.

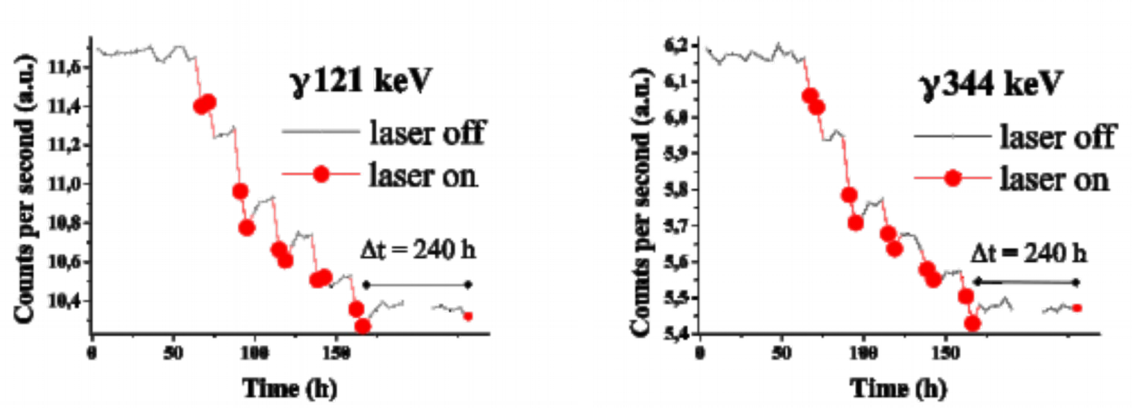

Fig.1.The change in the intensity of the gamma line 121keV,344 keV ^{152}Eu is shown in the figure.

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MAGIC - HOW MATTER'S EXTREME PHASES CAN BE REVEALED IN GRAVITATIONAL WAVE OBSERVATIONS AND IN RELATIVISTIC HEAVY ION COLLISION EXPERIMENTS

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GSi Helmholtzzentrum fuer SchwerIonenforschung Darmstadt

This talk combines a survey of our recent advancements in two rather distinct fields, which reveal - on first sight - a surprising similarity of both, namely relativistic collisions of nuclei and of neutron stars.

Recently, the group at FiAS and at Goethe University discovered that the emitted gravitational waves, as predicted from general relativistic magneto- hydrodynamics from binary neutron star merger - calculations, are extremely sensitive to the appearance of quark matter and the stiffnes of the equation of state of QCD Matter in the inner cores of the two colliding Neutron Stars, as also in their gravitational collapse to one black hole. This is a new observable messenger from outer space, which does provide direct signals for the phase structure of strongly interacting QCD matter at high baryon density and high temperature.

Those astrophysically created extremes of thermodynamics do match , to within 20% , the values of temperatures which we find in relativistic hydrodynamics and transport theory of heavy ion collisions at the existing laboratories like LHC, SpS at Cern, RHIC at Brookhaven, and HaDes - SiS18 at GSi and at the NICA and FAIR accelerators under construction, if though at quite different rapidity windows, impact parameters and bombarding energies of the heavy nuclear systems.

We demonstrate how the gravitational wave signals from future advanced LIGO-Virgo - to radiowave signals from SKA-events can be combined with the high multiplicity fluctuation - and flow measurements in heavy ion detectors in the lab to pin down the EoS and the phase structure of dense matter.

THE EFFECT OF FINAL STATE INTERACTIONS IN TWO-PION AND $K\overline{K}$ TRANSITIONS OF CHARMONIA AND BOTTOMONIA

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The decays $J/\psi \to \phi(\pi\pi, K\overline{K})$, $\psi(2S) \to J/\psi\,\pi\pi$, $Y(4260) \to J/\phi\ \pi\pi$ and two-pion transitions among bottomonia states are considered in fact jointly with the isoscalar S-wave processes $\pi\pi \to \pi\pi, K\overline{K}, \eta\eta$ which were analysed earlier in our model-independent method based on analyticity and unitarity. When adding to the analysis data on the additional decays, it is obtained further confirmation of the fact that the basic shape of dipion and $K\overline{K}$ mass spectra in the indicated charmonia and bottomonia decays are explained by an unified mechanism based on the contribution of the $\pi\pi$, $K\overline{K}$ and $\eta\eta$ coupled channels including their interference. The role of the individual f_0 resonances in making up the shape of the dipion mass distributions in the charmonia and bottomonia decays is considered. When analyzing the decay $Y(4260) \to J/\psi\ \pi^+\pi^-$, some indication is obtained that the charmonium $X(4260)(Y(4260))$, the dipion spectrum of which is published in [Z.Q.Liu *et al.* (Belle Collaboration), Phys. Rev. Lett. **110**, 252002 (2013)], is a third radial excitation, i.e. the $4S$ state with the mass 4.3102 GeV.

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IMPACT OF AVERAGE NEUTRON ENERGY ON THE FAST NEUTRON FLUENCY MEASUREMENT BY Np-237 FISSION TO CAPTURE RATIO AND REVERSE DARK CURRENT OF PLANAR SILICON DETECTOR METHODS

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It is a subsequent step of feasibility study of fast neutron fluency measurement using two different complementary methods.

The idea of the first method is to search the neutron energy for the ratio of fission cross section to capture cross section of the selected actinide isotope from the nuclear data base that is equal to the measured ratio of fissioned and captured actinide isotope Np-237.

The idea of the second method is measurement of fast neutron irradiation induced reverse dark current increase of planar silicon detectors which is linearly proportional to neutron fluence.

We have focused on the efficiency dependence of incineration the minor actinides on the distance of their samples from the neutron spallation source. So far, we have not been able to place actinide samples in any place other than the lead specimen window.

We have processed the experimental data of irradiated Np- 237 actinide samples and silicon detectors directly placed on sections 2 and 4 of the QUINTA setup without lead shield-reflector. These samples were 12 cm from the source of the neutron spallation source, what is about 8 cm closer than before when we placed the actinides samples in the window of the lead shield-reflector.

Applying the try and error method we find the neutron energy for which the ratio of fission cross section to capture cross section of the actinide Np-237 from the nuclear data base is equal to the measured ratio of fissioned and captured actinide isotopes. It means that the retrieved distinct fission and capture cross sections for the distinct neutron energy from the nuclear data base describe the average values because the measured ratio (spectral index) is defined as the ratio of average fission and capture cross sections. The obtained values for average fission and capture cross sections let us to evaluate the neutron fluencies.

Given the considered above experimental data and the earlier obtained data we have found that the higher is the average neutron energy the smaller is the difference of neutron fluency measurement between the two methods. This effect was expected since the silicon detector method effectively measure the fast neutrons of energy higher than 170 keV.

ANISOTROPIC FLOW MEASUREMENTS FROM LHC TO SIS

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National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)

Extensive measurements of azimuthal anisotropy in relativistic A+A collisions, have provided invaluable insights on the expansion dynamics and the transport properties of the strongly interacting matter produced in such collisions. The recent results of flow measurements from the top LHC energy (5.2 TeV) to the top SIS energy (2.4 GeV) will discussed with emphasis on techniques, interpretation, and uncertainties in the measurements. The prospects for future measurements at NICA energies will be presented and discussed.

THE DIFFERENTIAL CROSS SECTION FOR DP-ELASTIC SCATTRING AT 500-900 MEV/N AND LARGE TRANSVERSE MOMENTA

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The results of the differential cross section elastic *dp*-scattering measurements at 500-900 MeV/n, performed at Internal Target Station at Nuclotron JINR are presented. The measurements have been performed on the unpolarized deuteron beam using CH_2 and C targets. The data were obtained for angular range 70°–120° in the c.m.s. The angular dependence is compared with the world experimental data at close energies as well as with the theoretical calculations performed within the framework of the relativistic multiple scattering theory. Differential cross section at fixed scattering angles cover a total c.m. energies $\sqrt{s}$ = 3.1 - 3.42 GeV were obtained. The results are compared with the behavior of the world data.

POLARIZATION IN HIC: COMPARISON OF METHODS

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2. *ITEP*

The polarization of hyperons in Heavy-Ion collisions is considered. The model of mesonic superfluid with quantized vortices is suggested [1]. The different methods of its polarization calculation are systematically compared[2]. The polarization as a branch of anomalous transport contains similarity and difference to hydrodynamical methods. The numerical simulations allow to compare the contribution of holographic anomaly to the data[3].

[1] From the chiral vortical effect to polarization of baryons: A model
Oleg V. Teryaev, Valentin I. Zakharov Published in Phys.Rev. D96 (2017) no.9, 096023

[2] Anomalous current from the covariant Wigner function
George Prokhorov, Oleg Teryaev
Published in Phys.Rev. D97 (2018) no.7, 076013

[3] Hyperon polarization in heavy-ion collisions and holographic gravitational anomaly
Mircea Baznat, Konstantin Gudima, Alexander Sorin, Oleg Teryaev
Published in Phys.Rev. C97 (2018) no.4, 041902

STUDY AND MONTE CARLO SIMULATIONS OF CENTRAL REGION OF URANIUM TARGET QUINTA IRRADIATED WITH HIGH-ENERGY PROTON AND DEUTERON BEAMS

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Spent nuclear fuel management represents a serious worldwide issue. One possible option of nuclear waste reduction is the accelerator driven system (ADS) use. The ADS research has a long tradition in the Joint Institute for Nuclear Research (JINR). Experiments of simple-geometry setup irradiation are performed on a regular basis in JINR for decades. These setups are usually composed of a spallation target (lead, uranium) and a subcritical blanket (natural or depleted uranium) and are irradiated by high-energy proton or deuteron beams. The JINR accelerator fleet offers the usage of a 660 MeV proton beam from Phasotron accelerator and 1 - 12 GeV proton and deuteron beams from Nuclotron accelerator. Due to spallation and fission reactions, huge neutron fields are created inside the setups. Neutron flux and radionuclide production is measured by activation detectors and evaluated by activation techniques.

Results' overview of experiments of irradiation subcritical assembly QUINTA by 660 MeV proton beams and by 4 GeV and 8 GeV deuteron beams will be presented. Activation foils of aluminium, cobalt and lead were used and radionuclide production along the beam passage in QUINTA was investigated. Comparison of the experimental results to Monte Carlo simulations will be discussed.

SPECTRA OF NEGATIVE PARTICLES IN Au+Au COLLISIONS FROM BES-I AT RHIC AND z-SCALING

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We present results of a new analysis of negative charged particle yields in $Au + Au$ collisions as a function of transverse momentum obtained by the STAR Collaboration for the first phase of the RHIC Beam Energy Scan Program in the framework of the z-scaling approach. The spectra were measured over a wide range of collision energy $\sqrt{s_{NN}} = 7.7 - 200$ GeV and transverse momentum of produced particles in different centralities at $|\eta| < 0.5$. Scaling behavior of the spectra as a function of a collision energy and centrality in z-presentation is verified. The concept of the z-scaling based on fundamental principles such as self-similarity, locality, and fractality of hadron interactions at a constituent level at high energies is discussed. The microscopic scenario of hadron production in terms of constituent momentum fractions and recoil mass of produced system is developed. The constituent energy loss as a function of energy and centrality of collision and transverse momentum of inclusive particle was estimated in the z-scaling approach. The present results indicate on self-similarity of fractal structure of nuclei and fragmentation process with negative charged particles produced in $Au + Au$ collisions. Discontinuty of the model parameters - the fractal and fragmentation dimensions and "heat capacity", are discussed from the point of view of the search for a phase transitions in the nuclear matter.

UPDATE ON THE SEARCH OF TWO PHOTON EXCHANGE IN ELECTRON PROTON ELASTIC SCATTERING

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Following Akhiezer-Rekalo method [1], polarized electron-proton elastic scattering allows a precise measurement of the electromagnetic proton form factor ratio, assuming that the interaction occurs through the exchange of one virtual photon (see Ref. [2] and References therein). The recently obtained results seem to show a disagreement with the common understanding that the electric and the magnetic form factors dependence on the transferred momentum should be similar. It was suggested that the reason of this discrepancy is related to an accidental increase of the exchange of two photons, above the expected order of α with respect to the Born approximation. Three experiments measured recently the cross section ratio of electron over positron elastic scattering on protons [3, 4, 5]. The deviation from unity of this ratio, *i.e.*, a charge asymmetry different from zero, is the signature of contributions beyond the Born approximation. After reviewing the published results, we discuss the applied radiative corrections and compare the elastic data to a calculation which includes the diagram corresponding to two-photon exchange [6]. It turns out that all the data on the cross section ratio, in the limit of their precision, do not show evidence of enhanced two-photon contribution beyond the expected percent level. Our analysis confirms that two-photon exchange can not constitute the explanation for the difference between unpolarized and polarized measurements of the proton electromagnetic form factors.

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FLUCTUATING SHAPES OF THE FIREBALLS IN HEAVY-ION COLLISIONS

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In each relativistic heavy-ion collision, strongly interacting bulk matter is created with different initial conditions. The initial conditions can only poorly be controlled. Moreover, during the evolution of the fireball, processes may happen, which are individual for every collision.

At the highest collision energies, like those probed at the LHC and RHIC, these are e.g. jets, which are always produced in different numbers and different directions. We have shown that the energy and the momentum which the jets deposit into hydrodynamicaly evolving bulk matter can lead to important contributions to the anisotropies of transverse collective expansion. Those, in turn, show up as anisotropies in final hadron distributions [1, 2]

At lower energies, like those studied in the RHIC Beam Energy Scan programme, or at the planned NICA and FAIR facilities, irregularities may appear due to the passage of the matter in vicinity of the critical point.

For the sake of obtaining higher statistics, data are usually examined from samples of a very large number of events. In such samples many of the fluctuating features of azimuthal hadron distribution may get averaged out. If there are events with some interesting structure, they would also be hidden in the large sample of many events. Therefore, we have proposed and studied a method for the selection of events according to their shape [3]. In a way, the paradigm is similar to the better known method of Event Shape Engineering [4]. However, our method of Event Shape Sorting does not make any bias as to how to select the events, it just sorts the events according to their similarity. I will show how the method works and present applications to studies of azimuthal anisotropies of hadron distributions and correlation femtoscopy.

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PROPOSED FIXED TARGET EXPERIMENT AT THE LHC BEAMS

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Physics opportunities of using the LHC beams for fixed target experiment developed in several publications, for example [1,2]. The main physical goals of the experiment are:

i) investigation of the large-*x* gluon, antiquark and heavy quark content in the nucleon and nucleus;

ii) investigation of the dynamics and spin of quarks and gluons inside polarized nucleus, using polarized target;

iii) study of the ion-ion collisions between SPS and RHIC energies towards large rapidity.

The ALICE and LHCb installations provide possibilities to use them in fixed target mode. For 7 TeV proton beam the energy in N-N centre-of-mass system is $\sqrt{s_{NN}}$ =114.6 GeV, and for 2.75 TeV Pb beam $\sqrt{s_{NN}}$ = 71.8 GeV. The energy of the particles reaches values of only two times less than at the RHIC collider, but the luminosity exceeds the luminosity of colliders many times. The experiment could investigate a wide rapidity region. ALICE muon arm together with a future MFT access the mid- to backward rapidity region (y_{cms} <0). ALICE central barrel probes end of phase space for very backward region.

Feasibility of using an internal gas target for fixed target experiment was shown by LHCb Collaboration with the SMOG system. Storage Cell gas target (like HERMES experiment) gives possibility to increase the gas density by several order of magnitude. It's also possible to use internal solid wire target in beam halo or to use a bent crystal to deflect a beam halo on internal solid target. Also in the extracted beam it is possible to install a polarized target. The project AFTER@LHC will study rare processes, polarization phenomena, will measure parameters needed to analyze the data of cosmic rays and neutrino astrophysics. The goal of experiment is also detailed study of quarkonia production and suppression depending on the phase transition of matter to the quark-gluon phase.

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HALF MASSES OF PARTICLES PRODUCED IN $\pi^- C$ INTERACTION AT 40 GEV/C AND PHASE TRANSITION

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In this paper we present the experimental analysis of the parameter T (temperature) as a function of the cumulative number n_c of π^- - mesons, K_0 - mesons and protons produced in $\pi^- C$ interactions at 40 GeV/c.

On the basis of this analysis we established a dependence between half mass of particle $(m_i/2)$ and the target mass value $(m_c = m_p n_c)$ which is required from the target for the production of the particle.

We suggest that the dependence between above mentioned two masses may be connected with the beginning of the mixed phase with constant temperature.

REACTION OF TWO PION PRODUCTION $pd \to pd\pi\pi$ IN RESONANCE REGION

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Search for dibaryon resonances in two-nucleon systems has a long history (for review see [1]). At present as one of the most realistic candidate to dibaryon is considered the resonance $D_{IJ} = D_{03}$ observed by WASA@COSY [2] in the total cross section of the reaction of two-pion production $pn \to d\pi^0\pi^0$, here I is the isospin and J is the total angular momentum of this resonance. The mass of the resonance is 2.380 GeV is close to the $\Delta\Delta$-threshold, but its width $\Gamma = 70$ MeV is twice lower as compared to the width of the free Δ-isobar. This narrow width is considered as the most serious indication to a non-hadronic, but most likely, quark content of the observed resonance state. The spin-parity of this resonance $J^P = 3^+$ were established by polarized measurements, however information about its production (decay) channels is non-complete. One possible mechanism of the reaction $pn \to d\pi^0\pi^0$ suggested in paper [4] involves sequential excitation and decay of two dibaryon resonances, $D_{03}(2380)$ and $D_{12}(2150)$. Very similar resonance structure was observed by ANKE@COSY in the differential cross section of the two-pion production reaction $pd \to pd\pi\pi$ at beam energies 0.8-2.0 GeV with high transferred momentum to the deuteron at small scattering angles of the final proton and deuteron [3]. In the distribution over the invariant mass M d of the final d system the resonance peaks were observed at M d 2.380 GeV [3] that is the mass of the isoscalar two-baryon resonance $D_{IJ} = D_{03}$, while the kinematic conditions differ considerably from that in Ref. [2]. We apply here the two-resonance model [4] to the reaction in question by inclusion of the σ-meson exchange between the proton and deuteron. Since not all required partial width were know from analysis [4] and quark model [5], we discuss only the shapes of the distributions over the invarinat masses of the final $d\pi\pi$ and $\pi\pi$ systems and find a qualitative agreement with the ANKE data [3].

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Δ-ISOBAR CONTRIBUTION TO THE PION PRODUCTION IN THE REACTION $pp \to \{pp\}_s\pi^0$

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The resonance structure observed in the total cross section of the reaction $pp \to d\pi^+$ with the maximum at about 600 MeV was explained by the Δ-isobar excitation in the intermediate state [1]. New analysis performed in Ref. [2] shows, however, that the pure Δ-mechanism is not sufficient to explain the absolute value of the total cross section of the reaction $pp \to d\pi^+$ and therefore dibaryon contributions were considered in [2]. In this situation it is important to study another channel of this reaction, $pp \to \{pp\}_s\pi^0$, at similar kinematics conditions but with formation of the diproton $\{pp\}_s$ in the final state with small excitation energy $E_{pp} < 3$ MeV providing a dominance of the $^1S_0$ state. Due to difference of the spin and isospin of the deuteron and diproton the reaction $pp \to \{pp\}_s\pi^0$ provides an independent test for the dynamics of the single pion production in pp-collision. Recently data on the reation $pp \to \{pp\}_s\pi^0$ were obtained by ANKE@COSY collaboration at beam energies 0.3 – 0.8 GeV [3].

We analyze the reaction $pp \to \{pp\}_s\pi^0$ using one-loop diagrams with the subprocess $\pi^0 p \to \Delta \to \pi^0 p$ [4]. The parameters for the coupling constants and vertex form factors were taken from Ref. [5] describing the COSY data on the reaction $dp \to \{pp\}_s\pi N$ [5]. The model explains the position of the peak observed in [3] at 0.6 GeV for zero diproton scattering angle, but cannot describe anomalous slope of the angular dependence of the differential cross section in the peak region. The helicity amplitudes formalism is developed in Ref. [4] for the partial wave analysis of this reaction. It is shown that the main contribution is made by the $^3P_0$, $^3P_2$, $^3F_2$ states in the initial *pp*-channel. The Δ-model and helicity formalism can be applied for analysis of the new ANKE data on the resonance behaviour of this reaction at higher energies 1.5 – 2.5 GeV [6].

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STRING MODEL CALCULATION OF STRONGLY INTENSIVE OBSERVABLE FOR MULTIPLICITIES IN TWO WINDOWS

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In quark-gluon string model we calculate the strongly intensive variable

$$\Sigma(n_F, n_B) \equiv [\langle n_F\rangle\, \omega_{n_B} + \langle n_B\rangle\, \omega_{n_F} - 2\,\mathrm{cov}(n_F\, n_B)]/[\langle n_F\rangle + \langle n_B\rangle] \tag{3}$$

for the charged particles multiplicities n_F and n_B in forward and backward rapidity windows, introduced like in [1] to suppress the contribution of the "volume" fluctuations in hadronic interactions at high energy ($\omega_n = D_n/\langle n\rangle$ is a scaled variance). We express this observable through the fundamental characteristics of a string: the multiplicity μ_0 per unit of rapidity and the two-particle correlation function $\Lambda(\eta_1 - \eta_2)$, describing the fragmentation of a single string. In particular we show that at mid-rapidities for symmetric reactions and small symmetric observation windows of a same width ($\delta\eta_F = \delta\eta_B \equiv \delta\eta$)

$$\Sigma(n_F, n_B) = 1 + \mu_0 \delta\eta\, [\Lambda(0) - \Lambda(\Delta\eta)]\ , \tag{4}$$

where $\Delta\eta$ is a distance between the centers of these two observation windows. This confirms the strongly intensive character of the observable in the case with fluctuating number of identical strings. It does not depend on the average number of strings, nor on the magnitude of event-by-event fluctuation of their number. By (4) we analyze the properties of the $\Sigma(n_F, n_B)$. For this we use the information on the two-particle correlation function of a string, $\Lambda(\Delta\eta)$, obtained in paper [2] by a fitting of the experimental pp ALICE data [3] on forward-backward correlations between multiplicities in windows separated in rapidity and azimuth in the framework of the model with independent identical strings.

We also consider the strongly intensive observable (3) taking into account the particle charge sign. In the case of charge symmetry, which is a very good approximation for mid-rapidity region at LHC collision energies, these charge-wise strongly intensive observables are expressed through the string pair correlation functions for particles of the same and opposite signs, $\Lambda^{same}(\Delta\eta)$ and $\Lambda^{opp}(\Delta\eta)$. We get information about these two functions by using the relations:

$$\Lambda(\Delta\eta) = [\Lambda^{opp}(\Delta\eta) + \Lambda^{same}(\Delta\eta)]/2, \quad B(\Delta\eta) = [\Lambda^{opp}(\Delta\eta) - \Lambda^{same}(\Delta\eta)]/2,$$

where $B(\Delta\eta)$ is the so-called balance function, measured by ALICE [4]. Then we calculate the strongly intensive observables taking into account the sign of the particle charge.

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TERNARY SŨ(3)-GROUP SYMMETRY AND ITS POSSIBLE APPLICATIONS IN HADRON-QUARK SUBSTRUCTURE. TOWARDS A NEW SPINOR-“FERMION” STRUCTURE

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Questions about the existence of three color quark symmetries and three quark-lepton generations could have a single nature associated with new exotic symmetries outside the Cartan-Killing-Lie algebras / groups. Our long-term search for these symmetries began with our Calabi-Yau classification of spaces on the basis of the *n*-ary algebra of reflexive projective numbers and led us to the expansion of complex and hyper complex numbers in the framework of which we construct new Abelian and non-Abelian symmetries. One of the exceptional features of these symmetry groups is the appearance of new spinor *n*-dimensional structures that lead to an extension of the concept of spin.

We discuss some possible applications of these exotic n-spinor matter (maarcrions) on the quantization of quantization of a proton, on the one hand, and on the other on the geometric origin of three quark-lepton generations. It's natural to think that these new exotic states would be candidates for representatives of dark matter. We will also be interested in the detection of exotic *n*-spinor matter in the different experiments.

BEAM POWER GAIN FOR MASSIVE URANIUM TARGET UNDER RELATIVISTIC PROTON, DEUTERON AND CARBON NUCLEI IRRADIATION

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The experimental determination results of the relativistic beam power gain for deep-subcritical uranium assembly “QUINTA” (mass of natural uranium 512 kg) 0.66 GeV protons and 2 and 4 GeV/nuclon deuterons and carbon nuclei irradiation are presented. Irradiations were carried out at the accelerators “NUCLOTRON” and “PHASOTRON”, JINR, DUBNA. Beam power gain is determined by the following expression $(E_p+n_f*E_f)/E_p$, where E_p - the accelerated particle energy, n_f - the uranium fission numbers, initiated by the accelerated particle in the assembly, E_f - the fission energy. The fission numbers in the assembly were determined by numerical integration of the experimental spatial distributions of the uranium fission rates. The following beam power gain values for the uranium assembly "QUINTA" were obtained: p(0.66 GeV) – (2.2±0.1); d(4 GeV) – (2.9±0.2); d(8 GeV) – (2.8±0.2); ^{12}C(24 GeV) – (2.3±0.2); ^{12}C(48 GeV) – (2.4±0.2). In a number of Accelerator Driven System (ADS) projects, it is planned to use quasi-infinite assemblies with almost zero neutron emission generated within the assembly as a result of spallation reactions. Using the results of the study of R.G. Vasilkov et al. (AE, v. 44, 1978, p. 329) the beam power gain values of the “QUINTA” assembly were extrapolated for a quasi-infinite uranium assembly: $p(0.66\ GeV)_\infty$ – (8.1±0.4); $d(4\ GeV)_\infty$ – (11.6±0.8); $d(8\ GeV)_\infty$ – (11.2±0.8); $^{12}C(24\ GeV)_\infty$ – (8.6±0.7); $^{12}C(48\ GeV)_\infty$ – (9.1±0.9). The obtained results can be used in the ADS assemblies design.

$\pi J/\psi - D\bar{D}^*$ INTERACTION VIA THE QUARK EXCHANGE DIAGRAM

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Exotic hadrons reported in the heavy flavor sector have been one of the interesting topics in hadron and nuclear physics [1, 2]. Especially near the thresholds, the heavy quark symmetry inducing the mass degeneracy of heavy hadrons provides (i) the one pion exchange being the driving force of nuclei, and (ii) the many channel-couplings. Such effects are expected to produce an attraction and the hadron-hadron bound states, called hadronic molecules, near the hadron-hadron thresholds. On the other hand, an existence of thresholds induces the cusp structure which may be misinterpreted as a physical resonance [2]. Hence, careful analysis of the scattering is needed near the thresholds.

In order to discuss the dynamics near the thresholds, the hadron-hadron interaction is very important, while the high-precision interaction is not established yet in the heavy flavor sector. In Ref. [3], the Lattice QCD simulation by HALQCD indicates the importance of the $\pi J/\psi - D\bar{D}^*$ potential which is given by the charm quark (hadron) exchange process. Such interaction must be very short range interaction, but the mechanism is not understood yet. As for the standard method, the meson exchange potential such as the D meson exchange has been introduced. However, the interaction range of the D meson exchange is about 0.1 fm, which is smaller than the hadron size, typically 1 fm.

Understanding the $\pi J/\psi - D\bar{D}^*$ potential is important in the studies of the Exotic hadrons which couples to a quarkonium. To describe this potential, we introduce the quark exchange process instead of the meson exchange one. The meson-meson scattering is described by the Born-order quark exchange diagram [4]. The meson wavefunctions and the quark interaction are given by the constituent quark model, where the parameters are fixed to reproduce the meson mass spectra. In this study, the cross section and the energy dependent potential for the $\pi J/\psi - D\bar{D}^*$ process are computed. We find that the hyperfine (spin-spin) and linear potential terms of the quark interaction plays an important role, while the coulomb one plays a minor role. We also find the difference between the results of the D meson exchange and the quark exchange calculations.

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CALCULATION OF FIELD OF SPECTROMETRIC MAGNET WITH 0.13 M GAP

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The spectrometric SP-94 magnet is widely used in experiments on high-energy physics and a number of other fields. In this report we present the results of calculating the magnetic field for a variant of a magnet with an interpolar gap of 0.13 m. Our spectrometer magnet has external dimensions of 2.95 x 2.12 x 1.62 m and an aperture (occupied by the beam) of 0.30 x 0.13 m.

The simulation was carried out using an integral method of magnetostatics. The corresponding formulas and algorithms for solving the magnetostatic problem are given.

The results of the calculated field distribution of the analyzing magnet with interpolar 0.13 m gap are given. The calculation was performed for the volume 0.33 x 0.0645 x 1.02~m, the volume of overlapping dimensions. Described in the work the calculation of the spatial distribution of the three components of the magnetic field of the magnet are conducted to obtain information about the magnitude and uniformity of the magnetic field for different modes of operation of the spectrometer.

Planned to use the obtained results in the processing of physical data.

DESCRIBING PHASE TRANSITIONS IN FIELD THEORY BY SELF-SIMILAR APPROXIMANTS

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Self-similar approximation theory is shown to be a powerful tool for describing phase transitions in quantum field theory. Self-similar approximants present the extrapolation of asymptotic series in powers of small variables to the arbitrary values of these variables. The approach is illustrated by considering three problems: (i) The influence of the coupling parameter strength on the critical temperature of the $O(N)$-symmetric multicomponent field theory. (ii) The calculation of critical exponents for the phase transition in the latter theory. (iii) The evaluation of deconfinement temperature in quantum chromodynamics. The results are in good agreement with the available Monte Carlo simulations, Padé-Borel summation, and lattice data.

RELATIVISTIC INVESTIGATION OF THE TRITON IN THE BETHE-SALPETER-FADDEEV APPROACH

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Three nucleon system(triton) was considered. Relativistic properties of this system were investigated. For this relativistic generalization of Faddeev approach was used. As two particle T-matrix which contained in relativistic Faddeev equation we used solution of Bethe-Salpeter equation. So eventually we had Bethe-Salpeter-Faddeev(BSF) equation for describe three nucleon system. As potential of nucleon-nucleon(NN) interaction we used saparabel potential. Form factors of this potential taken in Yamaguchi-type function. Using of separable potential in particular allow to reduce integration on two variables into integration on one variable in BSF equation. Six states 1S0, 3S1, 3D1, 3P0, 3P1 and 1P1 with different angular momenta were considered. For this we made particle wave decomposition of BSF equation.
System of 12 integral equations(for real and imaginary parts of amplitudes of 1S0, 3S1, 3D1, 3P0, 3P1 and 1P1 states) was solved with used iteration method. Bound state energy of triton and amplitudes of S,P and D states was found. Amplitudes used for calculation electric and magnetic form factors of triton.

OBSERVATION OF THE HOYLE-STATE IN DISSOCIATION OF RELATIVISTIC ^{12}C NUCLEI IN NUCLEAR TRACK EMULSION

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Recently it is suggested to search in relativistic ^{12}C dissociation for α-particle triples in the second excited state 0^{+}_{2} of the ^{12}C nucleus (the Hoyle state). The relevant events are identified by invariant mass values calculated on a basis of measurements of α-particle emission angles. HS events are observed in dissociation $^{12}\text{C} \rightarrow 3\alpha$ at 4.5 *A* GeV/*c* and 1 *A* GeV/*c* ^{12}C nuclei with a contribution preliminary estimated to be of the order of 10-15%.

OVERVIEW OF RECENT EXPOSURES OF NUCLEAR TRACK EMULSION IN THE BECQUEREL EXPERIMENT

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Preserving a status of a universal and inexpensive detector, the nuclear track emulsion (NTE) with unrivaled resolution and completeness ensures the observation of tracks beginning with fission fragments and down to relativistic particles. Development of a study of formation of triplets of alpha particles in the Hoyle's state arising in dissociation of relativistic ^{12}C nuclei in a nuclear track emulsion is presented. The analysis of layers transversely irradiated by muons with an energy of 160 GeV at CERN and about 2.5 GeV in the "muon torch" of the U-70 IHEP accelerator is in progress. In the disintegration of ^{12}C nuclei into three α-particles induced by relativistic muons a picture typical of nuclear diffraction appears. Preparation for a study of the uranium ternary fission excited by thermal neutrons in samples impregnated with a uranium compound is presented.

FRACTALITY IN HADRON INTERACTIONS: A CONSERVATION LAW AND QUANTIZATION OF FRACTAL DIMENSIONS

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A microscopic scenario of constituent interactions in high energy collisions of hadrons and nuclei is studied. The concept is based on the z-scaling of inclusive spectra observed in a wide range of collision energies, multiplicity densities, momenta, and angles of detected particles. We bring arguments that, due to the fractality and self-similarity of hadron interactions assumed in the z-scaling scheme, there exists a symmetry parametrized at any resolution (scale) by elements from the space of the momentum fractions. The continuous symmetry is connected with a conservation law of new quantity named here "fractal cumulativity". In the initial state, the quantity characterizes cumulative property of internal fractal structures of the colliding objects. In final state, the cumulativity reflects aggregation property in fragmentation processes by production of inclusive particles. The conserved quantity is proportional to the corresponding fractal dimensions and is a simple function of the respective momentum fractions. Based on statistical ideas and entropy considerations we will demonstrate that the fractal dimensions possess quantum character. This results in quantization of fractal cumulativity characterizing hadron interactions at constituent level.

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NEW PIXEL DETECTORS FOR ALICE AT LHC AND FOR NICA EXPERIMENTS

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ALICE (A Large Ion Collider Experiment) was constructed to study the physics of extremely hot and dense hadronic matter, and in particular the quark-gluon plasma (QGP), which is formed in relativistic heavy-ion collisions at the Large Hadron Collider (LHC). The upcoming upgrade of ALICE [1] is motivated by new physics goals that could be reached after the LHC upgrade planned in 2020, which will allow an increase in the luminosity of Pb-Pb collisions by almost a factor ten. These include measurements of the heavy-flavor yields, their diffusion coefficients, thermalization processes and mass dependence, azimuthal anisotropy, as well as the study of thermal dileptons and charmonium yields at very low transverse momenta, and investigations of the space-time evolution of the QGP. To achieve these goals, it is critical to improve the spatial resolution on the reconstruction of secondary vertices and increase the efficiency of reconstructing the tracks of charged particles with low transverse momentum. To this purpose, a new silicon Inner Tracking System (ITS) tracker with much higher granularity, lower material budget, and higher readout rate capabilities than the one currently operated, will be installed in ALICE in 2020. The upgraded ALICE ITS will consist of seven concentric layers instrumented with Monolithic Active Pixel Sensors (MAPS) which were fabricated using a 180 nm CMOS Imaging Sensor process [1]. These sensors have a detection efficiency above 99%, a spurious hit rate below 10^{-8} /pixel/event, and a spatial resolution of about 5 μm, also after irradiation at doses in excess of 1MRad. The ALICE pixel sensor is also being considered as building block for the construction of the vertex and inner tracker of the Multi-Purpose Detector (MPD) [2] at the JINR NICA (Nuclotron-based Ion Collider fAcility).

This contribution will present the work carried out to characterize the ALICE ITS pixel sensors, including comprehensive studies with a variety of gamma and beta sources. The performance of irradiated sensors at different temperatures, including cryogenic temperatures, will also be presented.

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TRANSITION FORM-FACTOR OF $\pi\gamma \to \pi\pi$ IN NONLOCAL QUARK MODEL

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The transition form factor of gamma pion into pair of pions $F_{3\pi}$ is studied in a framework of nonlocal chiral quark model [1]. In local limit the result is in agreement with chiral perturbative theory and reproduce Wess-Zumino-Witten anomaly [2, 3]. Nonlocality does not change a value of transition form factor in chiral limit. On the physical threshold of reaction the form factor $F_{3\pi}$ was calculated in effective nonlocal model [4].

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SIGMA-HYPERONS IN NUCLEAR COLLISIONS AT ENERGY OF FEW GEV/C

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Perspectives of identifying and studying the mechanisms of Σ-hyperons formation (isotopic and charged ratios) at Nuclotron-based Ion Collider fAcility NICA are discussed. Investigation of ion-ion interactions at few GeV/c per nuclei energy is the main interest for searching new phenomena and phase transitions in range of high baryonic densities and moderate temperatures of nuclear matter. New discoveries in this area known before will be associated with a qualitatively new level of detectors and the progress in theory. In this paper, the possible extensions of physical program of planned measurements are considered. The possibility of measurement Σ-hyperons cross section and their correlations is discussed in order to understand properties of cold dense baryonic matter.

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A TRACK FINDING ALGORITHM FOR THE INNER TRACKING SYSTEM OF MPD/NICA

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Joint Institute for Nuclear Research (JINR)

At present, the accelerator complex NICA [1] is being built at JINR (Dubna). It is intended for performing experiments to study interactions of relativistic nuclei and polarized particles (protons and deuterons). One of the experimental facilities MPD (MultiPurpose Detector) [2] was designed to investigate nucleus-nucleus, proton-nucleus and proton-proton interactions.

As one of the possible MPD upgrade steps, an Inner Tracking System (ITS) based on the next generation silicon pixel detectors [3] is being considered to be installed between the beam pipe and the Time Projection Chamber (TPC). It is expected that such a detector will increase the research potential of the experiment for both the proton-proton (high luminosity) and nucleus-nucleus (high particle multiplicity) interactions. According to the proposed design, the MPD ITS will consist of five layers of silicon pixel detectors. The main purpose of the ITS is to provide a better precision of the primary and secondary vertex reconstruction and improve track reconstruction in the MPD in the region close to the interaction point.

The existing in the MPD track reconstruction method is based on the Kalman filter in the TPC. Its simple extension to the ITS is not adequate to fully exploit the potential of the new detector, therefore such a method can not be considered as a good tool to study ITS performance. That is why another algorithm, based on the cellular automaton approach, was developed. This paper describes the new track finding algorithm for the ITS of MPD and presents some performance results obtained on Monte-Carlo generated data of proton-proton collisions.

[1] Nuclotron-based Ion Collider fAcility web-site: http://nica.jinr.ru
[2] MultiPurpose Detector web-site: http://mpd.jinr.ru
[3] B.Abelev et al [ALICE Collaboration], J. Phys., G41 (2014) 087002

NLO AND FSR NNLO RADIATIVE CORRECTIONS FOR DRELL–YAN PROCESSES AT LHC

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The NLO electroweak and QCD radiative corrections to Drell–Yan process at extra large invariant dilepton mass M in fully differential form have been studied. The results are the compact expressions, they expand via Sudakov and collinear logarithms. The new G/N-method of taking into account of radiative events without any approximations is demonstrated. Both at the parton and hadron level the FORTRAN code READY gives fast convergence and a good coincidence for cross section and forward-backward asymmetry with other groups at $M \geq 0.5$ TeV.

Using the soft-photon approximation and on-mass-shell renormalization the compact formulas for the two-loop electromagnetic corrections of final state radiation (FSR) to four-fermionic process in s-channel are obtained. The scheme of effective numerical estimation of radiative effects of final state for the Drell–Yan process experiments at LHC with large invariant mass is proposed. We have also first result on leading log "hard" FSR NNLO radiative corrections to Drell–Yan process.

FULLY SOLVABLE MATHEMATICAL SCHEME FOR FINDING OUT THE RIGHT MASS AND WIDTH VALUES OF $f_0(500)$ AND $\rho^0(770)$ MESONS

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By using the worked out fully solvable mathematical scheme for finding explicit forms of the pion scalar-isoscalar and vector electromagnetic form factors as functions of the absolute value of the pion three-momentum in c.m. system of the elastic $\pi\pi$ scattering process one finds the most correct mass and width values of the $f_0(500)$ and $\rho^0(770)$ mesons.

RIGHT SIGN OF SPIN ROTATION OPERATOR

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For the fermion transformation in the space all books of quantum mechanics propose to use the unitary operator $\widehat{U}_{\vec{n}}(\varphi) = \exp\left(-i\frac{\varphi}{2}(\widehat{\sigma}\cdot\vec{n})\right)$, where φ is angle of rotation around the axis $\vec{n}$. But this operator turns the spin in inverse direction presenting the rotation to the left. The error of defining of $\widehat{U}_{\vec{n}}(\varphi)$ action is caused because the spin supposed as simple vector which is independent from $\widehat{\sigma}$-operator a priori. In this work it is shown that each fermion marked by number i has own Pauli-vector $\widehat{\sigma}_i$ and both of them change together. If we suppose the global $\widehat{\sigma}$-operator and using the Bloch Sphere approach define for all fermions the common quantization axis z the spin transformation will be the same: the right hand rotation around the $\vec{n}$-axis is performed by the operator $\widehat{U}^{+}_{\vec{n}}(\varphi) = \exp\left(+i\frac{\varphi}{2}(\widehat{\sigma}\cdot\vec{n})\right)$.

ANALYTICAL DESCRIPTION OF HADRON PRODUCTION IN HADRON-HADRON AND NUCLEAR-NUCLEAR COLLISIONS IN THE MID RAPIDITY REGION

A.I. Malakhov and G. Lykasov

Joint Institute for Nuclear Research

It is shown that the inclusive spectra of the produced hadrons in hadron-hadron and nuclear-nuclear collisions can be presented as the universal function dependent of the self-similarity parameter in analytical form. A description of the self-similarity parameter depending on the rapidity in the mid-rapidity region is obtained. The experimental data are in good agreement with results our calculations in a wide energy range from a few GeV to a few TeV in central rapidity region.

COHERENCE CONTROL OF TRIPLE ELECTROMAGNETICALLY INDUCED TRANSPARENCY AND AUTLER-TOWNES EFFECT USING AN ATOMIC MEDIUM

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In this contribution we analyze the interplay between the Autler-Townes phenomenon and the electromagnetically induced transparency in a five-level atomic system. This interplay is controlled by cyclically driving optical fields. The optical fields consist of two strong microwave, two strong optical- fields and a weak probe field. The comparison of both the effects in the system are studied with respect to the probe field transmission in the presence and in the absence of various decay processes.

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